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NEW YORK, FEBRUARY, 1890.

THE New York Railroad Commission in its annual report makes a number of recommendations to the Legislature as usual, some of them being a repetition of those made in former years, to which—as the Commission not unnaturally complains—the Legislature has not paid the slightest attention. The most important of these recommendations is that suggesting an amendment of the law providing for a review of the Commissioners' recommendations by the courts and their enforcement by action of the courts, should they be found just and reasonable. Akin to this is the recommendation that a penalty be provided for failure on the part of the companies to file the quarterly reports now required by law. Another important recommendation is that all future grade crossings of railroads and highways be prohibited by law, and that provision be made for the separation of grades between railroads and highways at crossings now existing.

One equally important is that the consent of the Railroad Commissioners be required before a new railroad company can be organized. This is intended to prevent unnecessary duplication of railroads and the construction of parallel roads which are not required.

The other recommendations are for acts to prevent discrimination; to establish responsibility in the case of damage by fire; to regulate the leasing of roads; to require the use of a center-bearing rail for street railroads; for the use of the railing on the tops of freight cars, to protect brakemen, and for the use of a thermometer in passenger cars.

THERE has been some revival recently of the project—which was originated, we believe, by Mr. H. R. Helper some years ago—for a railroad to connect North and South America, running through Mexico, Central America, and South America. It is possible that this project may be realized some day, but if so, it will be done by the gradual extension of the railroad systems of the different countries and their connection, and not by the construction of a single line.

Considerable progress in this direction has already been made in the building of railroads in Mexico, and much more will probably be done in that country and Central America during the next 10 years. In South America the building of the Pacific Railroad connecting the Argentine Republic with Chili, and crossing the continent from Buenos Ayres to Valparaiso, will probably be followed by an extension to and into Bolivia, now the most remote and inaccessible of South American countries, while a railroad through the valley of the Upper Amazon, connecting Bolivia and Brazil, and possibly Peru, also is among the probabilities of the near future. All of these roads will supply links in the proposed line, but the time when North and South America will have complete connection by railroad is still remote.

THE Marine Conference at Washington proved to be a more steady and hard-working body than such conferences generally are, and has really accomplished a great deal of useful work. A complete code of sound signals for use at night or in bad weather was adopted, and also a code of rules designed to prevent collisions. This includes distress signals for vessels requiring assistance, and also signals to indicate the course to be taken in clear weather when vessels can be seen.

General codes of rules for designating and marking vessels and also for saving life and property from shipwreck were adopted, and also uniform rules for reporting and marking wrecks and other obstructions to navigation, for buoys and beacons, and for notices of new dangers discovered.

The Conference decided that no international regulations to determine the seaworthiness of vessels could be made which would secure beneficial results, and also decided that it was not expedient for the present to establish any permanent International Commission. It was decided, however, to invite all maritime countries to take into consideration the use of a uniform system of storm-warnings, and that such a system should, as far as possible, indicate whether the storm is approaching or has passed the stations where they are displayed.

While the recommendations of the Commission are not binding upon the nations which they represent, they have been so carefully made and with such authority, that there is very little doubt that they will be adopted substantially by all the leading maritime powers.

TRAINS have at last begun to run over the great bridge across the Kills, between Staten Island and the New Jersey shore. The bridge has been finished for over a year past, but has not been in use, because the railroad connection on the New Jersey side was not completed. This has now been finished and trains are running to the Staten Island terminus.

The bridge itself has a draw-span 500 ft. long, with two fixed spans of 150 ft. each, being thus comparatively short. On the Staten Island side there are 6,000 ft. of trestle, and on the New Jersey side 4,000 ft. of trestle in the approaches. It is owned by the Baltimore & Ohio Railroad Company.

WORK has been resumed on the tunnel under the Hudson River between New York and Jersey City, as has already been noted. The north tunnel, starting from the New Jersey side of the river, has been pumped out, and some progress has been made upon its extension, and a

commencement of work has been made at the New York end. Nothing has as yet been done to the south tunnel, which had been extended some distance under the river when work was stopped in 1887. The project has been taken up by English capitalists who have agreed to furnish the funds necessary for carrying on the work, and it is understood that it will shortly be taken up by an English contracting firm, Pearson & Son, who will introduce new methods of work. They will use, it is said, what is known as the Greathead shield in making the excavations under the river. There are many questions as to terminal arrangements and the extension of the tunnel from the river line under the city in New York which are yet to be settled.

THE Board appointed by the Secretary of the Navy last summer, to lay down a general plan for the future increase of the Navy, has, it is understood, prepared a very extensive programme. It includes the building of 10 battleships of 10,000 tons displacement; eight of 8,000 tons; 12 of 7,000 tons, and five of 6,000 tons each; 10 rams of 3,500 tons displacement each; 15 torpedo cruisers of 900 tons each, to make not less than 22 knots an hour. This will complete the fighting or coast-defense fleet. The cruising navy under this plan would include nine armored cruisers of 6,250 tons displacement and 19 knots speed; four protected cruisers of 7,400 tons and 22 knots speed; nine protected cruisers of 5,400 tons and 20 knots speed; two protected cruisers of 4,000 tons and 19 knots speed; and five special cruisers of 1,200 tons and 18 knots speed. In addition to these there would be built as tenders three artificers' or engineers' ships, provided with appliances for repairing and for aiding vessels in distress. The construction of such a fleet, it is estimated, would involve an expenditure of nearly $280,000,000. Of course, it is not intended that all these vessels should be built or even commenced at once, but in the opinion of the Board it will require the whole number to constitute a navy of modern construction, and suitable to the dignity and power of the United States. It is proposed to extend the building of these vessels over a period of 14 years, about $20,000,000 per year being thus required.

THE Hale bill, which has been introduced into the Senate, provides that the Department be authorized to begin work on eight battle-ships, two armored coast-defense vessels, three gun-boats, and five first-class torpedo boats. All of these vessels will be in accordance with the general plan outlined by the Board. There is very little doubt that liberal appropriations will be made for the Navy this year, and not much doubt also that they will follow the general line of the recommendations of the Secretary, and will be for fighting ships rather than for cruising vessels.

THE total number of passengers carried by the New York City lines, as shown by their reports to the Railroad Commission for the year ending September 30 last, was as follows for two years:

	1889.	1888.
Elevated Lines	179,497,433	171,529,789
Surface Lines	209,386,816	205,383,797
Total	388,884,249	205,383,797

The increase last year over 1888 in the total number of passengers was 11,970,663; a gain of a trifle over 3 per cent. only. In 1888 the increase over the previous year was about 5 per cent., and in 1887 it was 11½ per cent. There was no reason last year for any extraordinary gain, but it is a little surprising that the movement remained so nearly stationary.

The greater part of the increase fell to the share of the elevated lines, which last year carried 46.2 per cent. of the total, against 45.5 per cent. in 1888, so that the conditions of travel in the city cannot be said to have changed to any great extent during the year. There was a greater increase, however, in the number carried by the cross-town lines than in those on the lines running up and down town, but the difference was not large enough to be notable.

Practically also, there were no additions to the length either of elevated or surface lines in the city, the only change being a short extension of the Suburban Elevated line, which is not as yet a very heavy passenger carrier, although it probably will be in the future.

Under these circumstances we would not expect any great change in the equipment. That of the elevated roads remains the same in number as the previous year—291 locomotives and 921 cars. The surface roads report 2,373 cars, an increase of 240, and 14,764 horses, an increase of about 1,200 in number.

Several changes are in contemplation on the city railroads in the way of substituting cables or electric power for horses, and, as is well known, there are numerous plans for new elevated railroads; but there have been no new developments during the year, and it is still somewhat doubtful whether there will be any during the present year.

INTERNATIONAL TRIAL OF LOCOMOTIVES DECLINED.

THE Secretary of the Edinburgh International Exhibition, to be held next summer, has written to *Engineering* saying that invitations have been addressed to the seven chief locomotive builders in the United States to send a representative American express engine for exhibition and practical trial, which have all been declined, on the ground that the expense would exceed any benefits likely to accrue. He says that the invitations provided for the American engines being worked throughout by American engineers, and stated that fair play in every respect would be guaranteed.

The Engineering Committee of the Exhibition have addressed a letter to the Baldwin Company, asking whether they would send an engine if all expenses were paid.

The Secretary says that, "when the idea was first mooted Americans in this country hailed it enthusiastically, and expressed confidence that an engine would not only be sent, but that it would be backed to beat the British ones to the tune of hundreds of thousands of dollars. It would seem that a change has since come over these views; but still it might reasonably be imagined that a sufficient number of public-spirited Americans could be found to provide the necessary funds to recoup the Baldwin Company for the outlay. Even should freight have to be paid on the engine, the total expense could not well exceed $5,000, a mere bagatelle to set against the loss of prestige to American builders which the declining of such an invitation must involve."

It appears then that the British Lion has knocked a chip off of the horns of the American Buffalo, and that up to date the tail of the Buffalo is quiescent. Why is this thus?

Where are Edward Bates Dorsey, Mr. Strong, and Mr. Lockwood? Messrs. Locomotive Builders, the American Eagle blushes for you.

FIRE-BOXES LINED WITH FIRE-BRICK.

THE *Railroad Gazette* is "rather surprised to find advocates of fire-boxes lined with fire-brick cropping out at this date, when the effects of the heat retained in that most valuable device, the brick-arch, are so well known to all who have tried to blow-off and quickly wash out locomotive boilers, equipped with it, after a hard run." It quotes the experience of an Eastern road on which a device which had a complete fire-box lining of considerable thickness was tried. The locomotive, it is said, made steam very slowly before starting, but "when the end of the run was reached, went on making steam as though it was never going to stop."

It is said further, that "the round-house fireman did not dare to leave the engine by itself for fear of burning the crown-sheet, and the crew were held until the fire-brick storehouse of heat had exhausted itself and cooled down to a safe temperature." From this slight and traditional evidence, it is concluded that "as a lining to cover up heating surface the presence of fire-brick is detrimental, and that theory which leads one to suppose that a locomotive fire-box would be better if lined throughout with a coating of brick is a delusive one, and one that has been tried and found wanting in practical value."

Who it is that proposes to use fire-brick as a lining to cover up heating surfaces does not appear. Certainly those who are successfully using fire-brick lined fire-boxes do not propose to "cover up heating surfaces" with it. Mr. Verderber did not, Mr. Urquhart, Mr. Liddell, the Erie Iron Works, nor the engineers who adopted it on various ships do not. If heating surfaces are not covered with fire-brick, it is difficult to see how, on heavy grades, "the well-known low heat conductivity of fire-brick would act to prevent the access of heat of the fire-brick to the furnace walls, and would thus have been an actual barrier to evaporation, and would have reduced the capacity of the boiler to furnish steam under a hard pull enormously." This "difficulty" is an imaginary one.

To the charge that such fire-boxes will generate steam after the fire is withdrawn, it may be said that some thousands of stationary boilers, with brick furnaces, are open to the same objection, and yet, quite curiously, we never hear of any trouble growing out of it. But let us see how much heat a fire-brick fire-box will hold. If the fire-brick is 5 in. thick, the lining of an ordinary box 6 ft. 6 in. long would weigh about 6,700 lbs.

It will also be supposed that at the end of the run this is heated to a temperature of 1,000°, and that the steam pressure is 150 lbs. Now the temperature of the water under a steam pressure of 150 lbs. is 366°. When the fire-brick is cooled down to that temperature, no more heat will be transmitted to the water. Consequently, it is only the difference between these temperatures, or 634° of heat, which can be transmitted to the water. The specific heat of brick is only one-fifth that of water, so that the amount of heat in the fire-brick which can be utilized in making steam would be ascertained by the following calculation, $\frac{6,700}{5} \times 634 = 849,560$, or, say, 850,000 units of heat. It takes 858.9 units of heat to convert a pound of water into steam of 150 lbs. pressure if the water is heated to the temperature of the steam. Therefore the heat in the fire-box would convert a little less than 1,000 lbs. of water into steam if all the available heat was transmitted to the water. This would be equivalent in effect to the combustion of about 140 lbs. of coal, on the improbable assumption that all the heat above 366° is transmitted to the water in the boiler. If this should actually occur, the obvious way out of the difficulty would be to burn 140 lbs. less of coal before the end of the run. In other words, if a fireman had not wit enough to adjust his fire to the new condition of things which would exist if fire-boxes lined with fire-brick were used, then the difficulties imputed by the writer in the *Railroad Gazette* would occur, but they might and sometimes do occur when anthracite coal is used for fuel, and might with other fuel.

It is true that fire-brick will take a longer time to cool than a boiler will without it, but considering the great advantages which would result if we could dispense with all fire-box plates, excepting the tube-sheet, all stay-bolts, crown-bars, and flanged sheets, which are the most expensive parts of a locomotive to construct and maintain, and considering the damage which is sometimes done by cooling boilers off too suddenly—none of which advantages does the writer in the *Gazette* seem to recognize—some stronger objection must be brought to the use of fire-brick than that of inconvenience in washing out the boiler to prevent such fire-boxes from being adopted. All that is advocated is that the apparent merits of this kind of fire-boxes make it worthy of a thorough trial. None of those who are now using them make the objections our contemporary does; perhaps it is because they have not given heed, as he has, to some story which is apparently little more than a tradition.

COUNTERBALANCING THE REVOLVING AND RECIPROCATING PARTS OF LOCOMOTIVES.

THIS is an old subject and has been under discussion for 40 or 50 years, but notwithstanding the fact that it has been talked and written about so much, it is still very imperfectly understood by many persons who are in positions where such knowledge would be useful to them and valuable to their employers.

As a prelude to an explanation of the principles of counterbalancing locomotives, it may be remarked that it is impossible to do it perfectly with the ordinary means that are employed for that purpose. The disturbance caused by the action of the reciprocating parts may be lessened up to a certain point, but there it becomes merely a choice between two evils—if one of them is diminished the other is increased, and *vice versa*—as will be explained further on.

If a revolving shaft or wheel of any ordinary machine has more weight on one side of its center than on the other—or is "out of balance," as it is called—the machine, unless it is very securely fastened, will shake when the shaft or wheel revolves rapidly; or, if the revolving part is free to move laterally, it will "wobble." This action is shown if we fasten a weight to one side of an ordinary spinning top; or, better still, by a model of a pair of locomotive wheels on an axle suspended from journal-bearings by elastic india-rubber bands, so that the wheels and axle can turn freely and swing horizontally. The elastic

bands will also allow the wheels and axle to vibrate vertically. If a twine is wound around the axle of a model thus suspended, and a weight is attached to the twine, the descent of the weight will cause the axle and wheels to revolve. If they are balanced they will have very little horizontal or vertical movement; but if a weight is attached to one of the wheels, at some distance from its center, and they are then made to revolve, they will vibrate more or less violently both vertically and horizontally in proportion to their speed, owing to the effect of the centrifugal force of the weight. This force is exerted away from the center of the axle in the direction of a radius drawn through the center of gravity of the weight and the center of the axle. As the wheel and the weight attached thereto are revolving, the direction in which this centrifugal force is exerted is continually changing, and pulls the wheel first in one direction and then in another, which causes it to vibrate sideways and up and down.

If an equal weight is attached to the opposite side of the wheel, and at the same distance from its center as the first one, then the centrifugal forces of the two weights will act in opposite directions and the two will balance each other, and there will be no disturbance in the revolution of the wheels, and if the weights balance each other accurately the wheels will have little or no lateral or vertical movement, showing that the centrifugal force of the one weight neutralizes that of the other. It is not essential, though, that the two weights should be equal to each other and at the same distance from the center of the wheel. All that is needed is that the products of the weights multiplied by their distance from the center of the wheel should be equal. Thus, if one weight is equal to 150 lbs. and its center of gravity is 12 in. from the center of the wheel, then it may be balanced by another weight of 90 lbs. 20 in. from the center of the axle on the opposite side, because $150 \times 12 = 1800$ and $90 \times 20 = 1800$.

The action of an unbalanced revolving weight is shown in fig. 6, in which A is a shaft, $c\,A$ a crank, and c a crank-pin, and C a weight attached to the crank-pin. When the crank is turning the tendency of the weight is to move in a straight line $c\,f$, tangent to the circle in which it is moving, and away from the center of the shaft. As the crank-pin moves in the dotted circle it constantly pulls the weight from a tangent path into the circular one in which the crank-pin is revolving. There is therefore a constant pull on the crank-pin away from the center of the shaft in every position of its revolution. This is equal to the centrifugal force of the revolving weight.

The amount of this pull may be ascertained by the well-known rule for calculating centrifugal force, which is as follows:

Multiply the weight of the revolving body in pounds, the square of the number of revolutions per minute, the radius or distance in feet from the center of motion, and .00034 together, and the product will be the centrifugal force.

The effect of an unbalanced weight at the crank-pin of a locomotive driving-wheel is illustrated by figs. 1–5, in which the large circles represent the circumference of a driving-wheel in four different positions. A is the axle and C the crank-pin and W a weight attached to the crank-pin. When the wheel is revolving, and is in the position shown by fig. 1, the weight W will exert a centrifugal force against the pin in a direction away from the axle, as indicated by the dart d. The effect of this is that a pressure is communicated to the axle which pushes against the driving-box and frame, and the force thus has a tendency to move that side of the engine ahead, if it is running in the direction indicated by the dart K.

When the crank-pin is in the position shown in fig. 3 the centrifugal force of the weight again acts away from the center of the wheel and pushes the crank-pin and wheel backward. In the position shown by fig. 2 it pushes downward and in fig. 4 upward, as indicated in each case by the darts d. When the crank-pin is in the position shown by the dotted circle c, fig. 1, the centrifugal force is exerted in a diagonal direction, as indicated by the dotted dart $c\,A$.

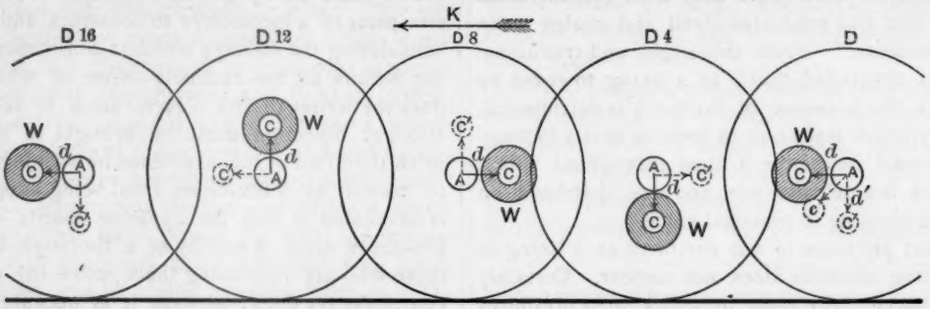


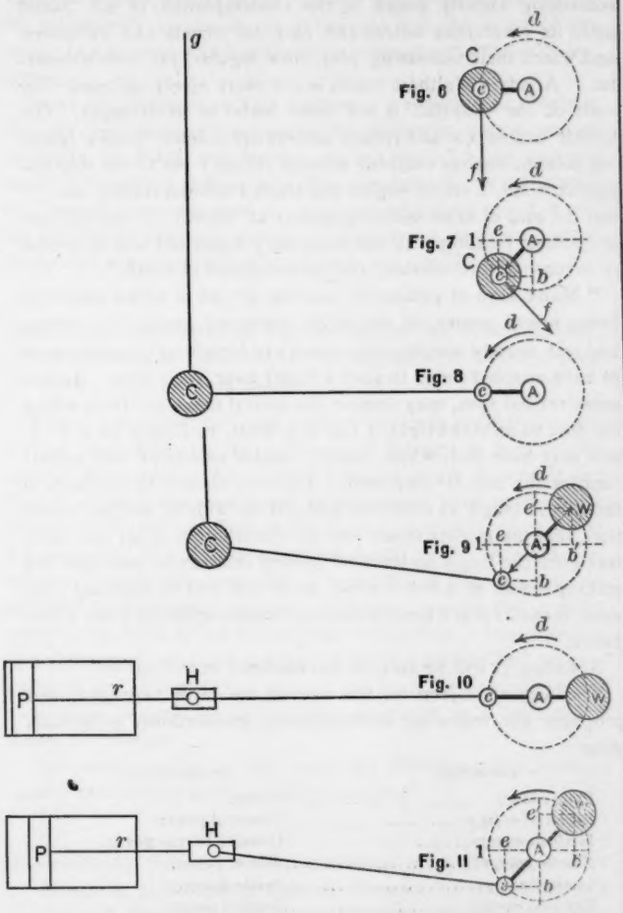
Fig. 5 Fig. 4 Fig. 3 Fig. 2 Fig. 1

When the crank-pin C, on the nearest side of the engine, is in the position represented in fig. 1, the crank-pin on the opposite side is in the position represented by the dotted circle C'. The centrifugal force of the revolving weight on this crank-pin is then exerted downward, or in the direction of the dart d'. In fig. 2 the centrifugal force on C' pushes backward, in fig. 3 upward, and in fig. 4 forward. When the centrifugal force is exerted either forward or backward on one side of a locomotive, the tendency is to produce what is called "nosing," or a horizontal movement of its front or back ends around a vertical axis between them, or a longitudinal jerking motion. When either of the crank-pins is above the axle, as in figs. 3 and 4, the upward pressure on one side has a tendency to lift that side of the engine; or, if either is below the axle, as in figs. 1 and 2, the centrifugal force is exerted downward and presses on the rail below the wheel.

As explained above, a revolving weight may be balanced in so as to cause very little disturbance, by simply putting a counterweight in each wheel opposite the crank-pin, whose weight, multiplied by the distance of its center of gravity from the center of the axle, will be equal to the weight at the crank-pin multiplied by the distance of its center from that of the axle, or half the stroke. In a locomotive the revolving weights of each wheel consist of the crank-pin boss, crank-pin, one-half the coupling-rod or rods connected to the wheel. For each of the main driving-wheels, there must be added to these weights that

of the back end of the main connecting-rod. When the main rods are connected to the inside journals of the crank-pins—that is, to the journals nearest to the wheels—a weight in the wheels equivalent to that at the crank-pins gives a sufficiently perfect balance of the revolving parts for all practical purposes, but when the main rods are connected to the outside journals, the counterweights should be modified somewhat, as will be explained further on.

It remains to explain how the reciprocating parts may be balanced. Supposing that *c A*, fig. 6, is a crank on the shaft or axle *A*, and revolving around it, and that *C* is a weight attached to the crank-pin *c*. If the crank is revolving in the direction indicated by the dart *d*, then the



weight, if unconstrained, would move in a direction at right angles to *A c*, as indicated by the dart *c f*. Instead of being free to move in that direction, the crank, as has been explained, pulls the weight toward the center of the wheel and causes it to revolve in a circular path around the axle. As the weight resists this constraint, considerable pull must be exerted by the crank to draw the weight *C* from the path *c f*, which it would take if it was detached from the crank when it reached *c*.

This pull is the centrifugal force of the revolving weight. When it reaches the position shown in fig. 7, if it was free to move, it would take the direction *c f* at right angles to the crank *c A*, but the crank continues to pull it toward the center of the shaft *A* in the direction *c A*, and compels the weight to revolve in a circular path. The centrifugal force exerted through the crank acts in a diagonal direction *c A*. By the principle of the parallelogram of forces, if we let the radius, *c A*, of the crank represent the magnitude of the centrifugal force and construct a parallelogram, *c c b a*, whose sides are vertical and horizontal and drawn through the centers of the shaft *A*, and crank-pin *c*, then the horizontal side *c b* will represent the force required to move the weight *C* horizontally. If instead of being attached to the crank the weight *C* was suspended by a cord *C g*, so that it could swing freely, as shown in fig. 8, and if the crank was at a dead point and the weight was connected to the crank by another cord or rod *C c*, then it is plain that to move the weight horizontally as much pull must be exerted on this rod as must be exerted by the crank in fig. 6. In other words, the resistance of the weight *C*, in fig. 8, to horizontal movement, when the crank is at a dead point, is just equal to the centrifugal force which would be exerted on the crank if the weight was attached to it. When the crank is in the position represented in fig. 7, it has been shown that the force required to move it horizontally is the horizontal component *c b* of the centrifugal force represented by *c A*. In fig. 9 the crank is represented in the same position as in fig. 7, and the weight *C* is again connected to *c* by a rod or cord *C c*. The force required to move *C* horizontally in this figure is the same as that required to move *C* in fig. 7, excepting as it is influenced by the angle of the connecting-rod *C c*, which may at present be disregarded. In other words, the force required to move *C* horizontally is equal to the horizontal component of the centrifugal force of a weight equal to *C* acting at the crank-pin. If, now, we were to put a counterweight *W* equal to *C* and opposite to the crank-pin *c*, fig. 9, then the centrifugal force of *W* would be equal to but would act in a direction, *A W*, opposite to that of *C* in fig. 7. Its horizontal component *e' W*, fig. 9, would be equal to but opposite to *c b* in figs. 7 and 9. Therefore *e' W*, or the horizontal effect of the centrifugal force of the counterweight *W*, will be equal to the horizontal force *c b* required to move *C*, and as they act in reverse directions they will balance each other.

From figs. 6 and 8 it may be observed that when the crank-pin is at the dead point, that the weight *C* is started from a state of rest, and that its motion is accelerated until the crank has made a quarter turn, and that its motion is then retarded to the end of the stroke, or until the crank reaches the back dead point. During the second half of the crank's revolution the movement of the weight *C* is again accelerated during the third quarter and retarded thereafter. The momentum of the weight *C*, acquired during the first and third quarters of the revolution, if not otherwise resisted, will press against the crank-pin and crank, and the reciprocating parts will thus be brought to a state of rest at the end of the stroke by the resistance of the crank. This produces an unbalanced pressure of the crank on one side of the shaft, which has a tendency to push it in the direction in which the pressure is exerted. As the shaft is revolving such a pressure is exerted alternately forward and backward. If, however, there is a counterweight *W* opposite to the crank, the horizontal component of its centrifugal force, as has been shown, is just equal to, and is exerted in the opposite direction to the momentum of the reciprocating parts, and thus balances them, and relieves the shaft of the horizontal disturbances due to the motion of the reciprocating parts.

Now the relation of the weight *C*, in figs. 8 and 9, to the crank is similar to that of the reciprocating parts of an engine, as shown in figs. 10 and 11, in which the cross-head

H is connected to the crank-pin *c* by the rod *H c*, and the piston-rod *r* and piston *P* are attached to the cross-head, and they are all moved together. When the crank is at the dead point, as shown in fig. 10, the force required to move the reciprocating parts horizontally is equal to the centrifugal force of a weight equal to these parts, acting at the crank-pin. Consequently, if we put a counterweight *W* equal to the reciprocating parts opposite to the crank, its centrifugal force will be just equal to the resistance of these parts and will be exerted in an opposite direction, so that it will balance or counteract the resistance and momentum of the reciprocating parts. When the crank is in any other position, as in fig. 11, then the horizontal component $e' W$ of the centrifugal force of *W* will always be equal to the horizontal resistance of the reciprocating parts, and they thus balance each other.

The discussion of this subject will be concluded in another article.

NEW PUBLICATIONS.

ALMANACH DES KRIEGSFLOTTEN (NAVAL ALMANAC), 1890: COMPILED BY THE EDITORS OF THE *Mittheilungen aus dem Gebiete des Seewesens*. Vienna, Austria; Gerold & Company.

It would be difficult to get information into a more condensed form than in this little book. It is of pocket size—5¼ × 3¼ in.—and its 220 pages contain what might almost be called a condensed encyclopædia of naval progress.

The book is divided into four parts. The first contains 34 pages of tables convenient for naval officers and engineers, giving the weights and measures of different countries, including sea-miles, knots, etc., tonnage measurement, displacement, and other specially nautical calculations.

Part II. covers 32 pages and gives in tabular form the types and calibers of artillery adopted by the navies of different nations, with tables giving the data obtained by experiment as to power, efficiency, penetration, etc., of different classes of guns.

Part III. contains, in its 110 pages, a list of the ships owned by every country possessing a navy, including vessels under construction. Judging by the section relating to our own Navy, it is evident that great pains have been taken to make these lists as full and accurate as possible, and to bring them up to the latest date. The United States makes a better showing in the list than might have been expected; but a very considerable part of its Navy is still marked as under construction.

The fourth part is made up by 128 sketches of war-ships, showing all the leading types of armored battle-ships in use in the navies of different countries. This part is exceedingly interesting. The engravings are, of course, small, but they are well executed and the subjects are well chosen, giving at a glance the peculiarities of all the principal types of modern battle-ships. The United States is represented here by sketches of the double-turreted monitor *Terror*, the new coast defense vessel *Monterey*, the *Maine*, and the *Texas*.

A convenient addition to the book is a number of blank pages prepared for memoranda and for entry of additional information gathered during the year. The book is in German, of course; for the naval officer conversant with that language no better pocket companion could be found.

THE STEAM ENGINE AND THE INDICATOR: THEIR ORIGIN AND PROGRESSIVE DEVELOPMENT; INCLUDING THE MOST RECENT EXAMPLES OF STEAM AND GAS MOTORS, TOGETHER WITH THE INDICATOR, ITS PRINCIPLES, ITS UTILITY AND ITS APPLICATION: BY WILLIAM BARNET LE VAN. Philadelphia; Henry Carey Baird & Company.

The Author in the opening sentence says that he has endeavored "to explain how, economically, to make use of steam in an engine, and has also discussed the most important principles regarding the *theory and action* of the steam engine, with a fair degree of technicality; and yet so as to be intelligible to the ordinary student."

This opening sentence and others in the book are not models of clearness. There are also some efforts at fine writing, for example the following:

"And to-day, viewing one of the gigantic engines to be seen in some of our large steamboats, who will deny that there is something awfully grand in the contemplation of it? Stand amid its ponderous beams and bars, its wheels and cylinders, and watch their increasing play, how regular, yet how wonderful! A lady's Waltham watch is not more nicely adjusted—the rush of the waterfall is not more awful in its strength. Old Gothic cathedrals and ruined abbeys are solemn places, teaching solemn lessons touching solemn things; but to the contemplative mind, a steam engine can teach a solemn lesson, too: it can tell him of mind wielding matter at its will; it can tell him of intellect battling with the elements; it can tell him of genius to invent, skill to fashion, and perseverance to finish."

"Many men of genius fill obscure graves in whose souls the living fire of poetry, or the bright sparks of genius, lay hidden and lost, merely wanting opportunity or fortuitous circumstances to have enabled them to shed a luster over their race. And in some retired spot, may remain the mortal tenement from which the soul of an Arkwright, a Davy, a Watt, an Evans, or a Webster may have fled, which merely wanted education and opportunities for this development. The fact should be a lesson to those who laugh at novelties and put no faith in further invention, that the mighty steam engine, the triumph of art and skill, was once the laughing-stock of jeering thousands, and once the waking dream of a boy's mind, as he sat, and in seeming idleness, mused upon a small column of steam spouting from a tea-kettle."

Spouting, it will be seen, is not confined to tea-kettles.

The Author objects to the use of the term "energy," and proposes the following substitutes or translations, as he calls them:

ENERGIES.	TRANSLATION.
Plain energy	Power.
Potential energy	Powerful power.
Intrinsic energy	Genuine or true power.
Kinetic energy	Motive power.
Internal energy	Inside power.
External energy	Outside power.
Equality of energy	Alike power.
Factor of energy	Terms of power.
Energy excited	Power that pushes.
Actual energy	Real power.
Mechanical energy	Power in mechanics.

Such work does not require serious criticism.

The book contains a history of the steam engine, which somehow writers seem to think no first-class treatise should be without. It may not be out of place to suggest here that histories of this kind usually occupy a wrong position. The natural way in which we acquire knowledge is not by going back a hundred or several hundred years ago and first finding out what was done then. A boy learns about a locomotive by seeing modern locomotives at work and learning from them what it is that makes the wheels go round. The historical method is the natural method turned upside down. It would in every way be better if the history of an art were given at the end of a treatise instead of at the beginning. It is safe to say

that, if it were reserved for the end, it would be seldom written or read.

Having pointed out some defects of Mr. Le Van's book, it remains to show its merits. The Author has for years been engaged as a mechanical engineer in Philadelphia, and has had an extensive experience in the use of the indicator. Much of the material of the book is evidently drawn from the results of this experience, and has a corresponding value. It deals with problems which every steam engineer must encounter, and discusses them in a way which every engineer can understand. The theoretical discussions thus have a practical flavor which is very agreeable in these days of rarefied speculation.

There is a chapter on the principles of the expansion of steam, and these principles are there very fully elucidated by indicator diagrams, evidently drawn from the experience of its Author. These form, as it were, a series of object lessons which emphasize the explanatory matter, so as to impress it on the mind of the reader in a manner which is easily understood and not easily forgotten.

There are chapters on Gas Engines; Automatic *vs.* Positive Cut-offs, and another containing miscellaneous matter, and an appendix in which are various tables, etc. The style of the book is somewhat diffuse, and the omission of the "fine writing" would have improved it; but even with these faults, it will be profitable reading, especially for young engineers, and, doubtless, for many whose youth is faded into the past.

THE DEVELOPMENT OF THE PHILOSOPHY OF THE STEAM ENGINE; AN HISTORICAL SKETCH: BY ROBERT H. THURSTON. New York; John Wiley & Sons.

This is a republication of a paper which was presented to the British Association for Advancement of Science, at their session held in Montreal in 1884. It is a review of the history of the theory of the steam engine and forms a small book of 48 pages, which will be an excellent guide to any one inclined to study the subject. The usefulness of the sketch would have been increased if the books containing the articles by different authors referred to were always given. It often happens that a reference to the work of an investigator would lead a reader to follow the subject up more fully if he knew where to find what is referred to. Without the title of the book or paper, as much time must be spent in finding what is sought as is required to study the subject.

The republication of his paper by Professor Thurston is timely and will be useful to many readers.

ELEMENTARY BUILDING CONSTRUCTION AND DRAWING: BY EDWARD J. BURRELL, SECOND MASTER OF THE PEOPLE'S PALACE TECHNICAL SCHOOLS, LONDON. London and New York; Longmans, Green & Company.

This book has been written with the idea that, in drawing an object, it is of the utmost importance that the student should understand very thoroughly its construction. The author therefore begins with a short chapter which gives little more than a description of the articles and instruments required in making drawings. The next is on brickwork, and the different methods of laying bricks and constructing walls, arches, etc., are described and illustrated very clearly. This is followed by Exercises thereon which will be understood best by quoting a few examples. Thus the first one is:

"Draw to a scale of $\frac{1}{12}$, figs. 5, 6, 8, 9 10, and 11, adding in each case an elevation of six courses of the brickwork, an elevation of the returned end, and a section on the line *C D*.

"6. Show about 6′ in length of a dwarf brick wall, 4′ high and 9″ thick, surmounted by one of molded brick copings, illustrated in fig. 34. Front elevation and section to be given. Scale $\frac{1}{12}$.

"10. Draw to a scale of $\frac{1}{4}$, figs. 43 and 44, showing the face arches complete."

The general plan is first to describe the methods of construction and then direct the student how to draw it. There are chapters on Stonework, Wood Joints used in Carpentry and Joinery, Floors, Partitions, Wood Roofs, Slating, Plumbing, Doors, Windows, Notes on Rolled Iron Joists, Cast-Iron Girders, Cantilevers, etc., Iron Roofs, and Materials used in Building Construction.

There are over 300 outline engravings, which are done by some "process" from drawings which were well executed, with the exception of the lettering and figuring, which are very badly done. The book is commended to those who want to study building construction.

THIRD ANNUAL REPORT OF THE INTERSTATE COMMERCE COMMISSION: THOMAS M. COOLEY, WILLIAM R. MORRISON, AUGUSTUS SCHOONMAKER, WALTER L. BRAGG, W. G. VEAZEY, COMMISSIONERS; EDWARD A. MOSELY, SECRETARY. Washington; Government Printing Office.

The Report of the Interstate Commerce Commission for 1889 is made directly to Congress, in accordance with a change in the law, and is, like its predecessors, a document which should receive the careful attention of all who are in any way interested in the railroad problems of the country—and these questions have an interest to every one engaged in the active affairs of life. If space permitted it would be a task which would be pleasant to us to enter at greater length than we are now able to do, into the questions discussed in the report, and to lay before our readers the conclusions and arguments which have been made by the Commission. We can only recommend them, however, to read the report themselves, and they will find that it will amply repay them as an educational exercise.

In the first pages the Commissioners give a statistical statement of the work of the past year, which shows that the positions they occupy are not sinecures, and the further pages of the report, giving the detail of that work in various directions, also show that it has been conducted with an intelligence, a careful desire to reach just and wise conclusions, and a regard for all the varied interests in their keeping, which reflects much credit on the members.

So much must be said in praise; in criticism we hesitate, because the critic is bound to justify his position, and on the points on which it might seem that the report called for such notice it would be necessary to enter into a more extended discussion, and one which belongs rather to the financial than the technical side of railroading. On another page we give some extracts from the report touching upon questions of a technical nature, which we recommend to the attention of our readers.

The Secretary, who, we suppose, is responsible for the "make-up" of the report, deserves the thanks of the readers for the manner in which that really important part of the work has been performed.

BOOKS RECEIVED.

REPORT ON THE INTERNAL COMMERCE OF THE UNITED STATES FOR THE FISCAL YEAR 1889. PART II OF COMMERCE AND NAVIGATION; WILLIAM F. SWITZLER, CHIEF OF THE BUREAU OF STATISTICS, TREASURY DEPARTMENT. Washington; Government Printing Office. This volume of the Internal Commerce Report gives statistics of the commercial, transportation, and other interests of Arkansas, Colorado, Dakota, Kansas, Missouri, Montana, Nebraska, New Mexico, Texas, and Wyoming.

A TEXT-BOOK ON ROOFS AND BRIDGES. PART II, GRAPHIC STATICS: BY MANSFIELD MERRIMAN, PROFESSOR OF CIVIL ENGINEERING IN LEHIGH UNIVERSITY, AND HENRY S. JACOBY, INSTRUCTOR IN CIVIL ENGINEERING IN LEHIGH UNIVERSITY. New York; John Wiley & Sons, 15 Astor Place (price, $2.50). This book is received too late for proper examination and review in the present number.

REPORTS FROM THE CONSULS OF THE UNITED STATES TO THE STATE DEPARTMENT: No. 109, OCTOBER, 1889. Washington; Government Printing Office.

REPORTS OF COMMITTEE ON ROADS, READ BEFORE THE ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA. Pittsburgh, Pa.; published by the Society.

QUARTERLY REPORT OF THE CHIEF OF THE BUREAU OF STATISTICS, TREASURY DEPARTMENT, RELATIVE TO THE IMMIGRATION AND NAVIGATION OF THE UNITED STATES FOR THE THREE MONTHS ENDING JUNE 30, 1889. Washington; Government Printing Office.

ANNUAL REPORT OF THE POSTMASTER-GENERAL OF THE UNITED STATES FOR THE FISCAL YEAR ENDING JUNE 30, 1889. Washington; Government Printing Office.

CORNELL UNIVERSITY, COLLEGE OF AGRICULTURE: BULLETIN OF THE AGRICULTURAL EXPERIMENT STATION, No. XIII, DECEMBER, 1889. Ithaca, N. Y.; published by the University.

TAYLOR IRON WORKS DIARY FOR 1890. High Bridge, N. J.; published by the Taylor Iron Works. This is a new edition of the very neat and convenient pocket diary which these Works have issued annually for a number of years past. The edition for 1890 is an improvement upon its predecessors in several minor particulars, and, indeed, leaves little to be asked for.

SPRAGUE ELECTRIC EQUIPMENT COMPANY: CATALOGUE OF ELECTRIC RAILROAD APPARATUS AND SUPPLIES. Chicago, Ill.; issued by the Company.

HOOPES & TOWNSEND'S CATALOGUE OF BOLTS, NUTS, RIVETS, AND KINDRED ARTICLES. Philadelphia; issued by Hoopes & Townsend, Manufacturers.

CATALOGUE OF STEAM SHOVELS AND WRECKING CARS MANUFACTURED BY THE BUCYRUS FOUNDRY & MANUFACTURING COMPANY: ILLUSTRATED. Bucyrus, O.; issued by the Company. This book contains illustrated descriptions and specifications of wrecking cars and steam shovels of various patterns. The Bucyrus Company's machinery is well known to engineers and railroad men; its excellence is attested by the number of its cars and excavators now in use on many different roads, and by the fact that the shops are always busy on new orders. The book is very tastefully printed, and the engravings are good.

HARRIS PALATIAL CAR COMPANY: PROSPECTUS. Boston, Mass.; issued by the Company. This is an illustrated description of the Harris car, which is a combined sleeping and parlor car on a new plan.

FINE TOOLS FOR ACCURATE MEASUREMENT: ILLUSTRATED CATALOGUE AND NET PRICE-LIST. Chicago, Ill.; C. B. James, No. 98 Lake Street.

ABOUT BOOKS AND PERIODICALS.

THE JOURNAL of the Military Service Institution for January contains articles on Mountain Artillery, by Lieutenant Parkhurst; Heavy Artillery Practice, by Lieutenant Foote; Danger from Lack of Preparation for War, by General Gibbon; and several other articles of much interest. There is also the usual variety of selected and translated articles, with the discussions on several papers read before the Institution.

The value of the date palm and the possibility of growing it in California are urged strongly upon the people of that State by S. S. Boynton, in an article published in the OVERLAND MONTHLY for January.

Two of the most interesting special articles in the CENTURY for January are the short notes on the Care of the Yosemite Valley, and on the Value of Small Colleges.

The December number of the JOURNAL of the New England Water-Works Association contains, besides the reports of the September and December meetings, two valuable papers—one on the Analysis of Water, by Professor Thomas M. Drown; and one on Water-Works Records, by Mr. Albert S. Glover, Water Registrar of Newton.

The second of the well-considered articles on the Merits and Defects of the National Guard, by Lieutenant W. R. Hamilton, appears in OUTING for January. Instantaneous Photography, in the same number, will attract the numerous votaries of that art; while all who are interested in outdoor sports and athletic exercises will find abundant material for their reading.

A rare picture of early New York is illustrated in the MAGAZINE OF AMERICAN HISTORY for January. In the same number Mr. James W. Gerard—than whom few men know New York better—treats of the Impress of Nationalities on that city in a thoughtful way, which is worth attention.

With the issue for January 4 the journal heretofore known as BUILDING appears with a new heading and with the name changed or enlarged to that of ARCHITECTURE AND BUILDING. The change is an appropriate one, expressing more fully and correctly the full scope of this valuable paper, and the wide field which it covers. At the same time two new departments—Architectural Engineering and Sanitary Engineering—have been added to the paper, both of which may be made of great service to architects.

The Western Railroad Situation meets with more careful consideration than is usual in an article by M. L. Scudder, Jr., in BELFORD'S MAGAZINE for January. Mr. Scudder's conclusions may not all be accepted, but he has a very clear idea of the situation and its causes; the cure for the present evils is yet to be found.

The Russian Army is eulogized by a Russian General in HARPER'S for January. His account is very interesting, certainly, and no one doubts the excellence of the Russian as a soldier, but a little criticism would, perhaps, have improved the article.

The Chattanooga TRADESMAN—an excellent and enterprising paper—marks the opening of the new year by an issue of 120 pages, containing a statistical review of the industrial growth and development of the Southern States in the 10 years just closed. The record is a notable one, and will surprise those who are not familiar with the subject. The review has required, evidently, a great deal of careful work, and deserves much credit.

Irrigation is treated of in the POPULAR SCIENCE MONTHLY for January by Henry J. Philpott. In an article entitled Two and a Half Per Cent., George Iles illustrates the widespread results of the very remarkable fall in the interest value of money which has taken place in the last 20 years.

In SCRIBNER'S for January the Household Applications of Electricity are described by A. E. Kennelly. Water Storage in the West is an illustrated article treating of the progress made in irrigating arid lands, which is now attracting so much attention.

CABLE TOWING ON CANALS.

To the Editor of the Railroad and Engineering Journal:

WITH regard to the points emphasized by M. le Chatelier in the paper translated and published in the November number of the JOURNAL, I would like to make some comments.

1. "The boat must be put in motion gradually"—that is to say, it must be started gently and made to take the speed of the cable gradually or by uniform increment of motion. This is a fact, and the condition gives rise, as M. le Chatelier says, to a difficulty. M. Oriolle's devices for overcoming this difficulty are his clutch—fig. 1 of your illustrations—and his spring-winding cone-seated capstan-like snubbing-heads shown in fig. 2. These devices serve the purpose—or are intended to serve the purpose—for which, in my system, I have provided a tow-line with a loop midway of its length—see Patent No. 371,680. This tow-line is to be man-handled by the boatmen through catching a turn of the towing end of the line around a kevel or big cleat fixed on the boat. The snubbing stress on the kevel, being regulated by the boatmen's hands, regulates the grip of the noosed tow-line on the cable. M. le Chatelier says that a loaded boat weighs 400 tons, but the boats on the Erie Canal are not large enough to give that dead weight of boat and cargo. A boat drawing 6½ ft. of water and having 17½ ft. beam, of the general model, very full every way, and 105 ft. in length over all, would displace about 355 net tons. I do not understand that French canal boats are nearly as large as our Erie boats, of which a few carry as much as 280 tons load each; but the favorite size for through traffic is only from 240 to 250 tons. The great hydraulic lift—illustrated in the JOURNAL for March, 1889—recently built in France has a capacity for boats of only about 70 tons; this, however, is by way of parenthesis.

As I was about to say, to start a loaded boat, and thereafter give her a speed of say 2½ miles per hour (or 220 ft. per minute), equal to that of the towing-cable, is an operation hardly to be effected in *one-seventh of a minute*, or while the towing-cable should travel 31.4 ft. only. But if M. Oriolle's spring-capstans are to wind down to a stand-still in *nine turns* (as stated), they would pay out only about 17 ft. of tow-line, providing the scale of fig. 2 and of fig. 1 aforesaid is one and the same. But suppose the capstans to be of 18 in. *diameter*, they would, in nine turns, pay out only about 42 ft. of line. At least five times this length of line would go out in the operation of snubbing on. I allow, in my rig, 500 ft. space between stops on my towing-cable. Some such rig as this capstan-gear might, if found desirable, be used as a safety-fast for the tow-rope, to ease up on the tow-line in case of any sudden surge; but for getting a move on the boat the fine hand of the boatman will be the approved instrumentality; he using my grip.

2. As to the clutch of M. Oriolle, it is of metal, and has projecting arms. How it would pass a cable-carrying roller I do not know exactly. My clutch, or grip, is of braided cord, and has no projecting attachments; it goes through the roller without shock.

M. le Chatelier says: "The cable must be in no danger of leaving the pulleys;" "it must remain strictly underailable." My cable may be made strictly underailable by a certain very simple contrivance devised by me for use in case of need; but with my grip there is no derailing-pull exerted by the tow-line on the cable. When the tow-line passes over my pulley-head the noose, or grip, of the tow-line has reached a position anywhere from 5 to 10 ft. away from (ahead of) the pulley; and there is absolutely no lifting force applied to the cable as it passes over the pulley or roller. Neither is there any lateral pull on the cable caused by the passage of the tow-line over the roller. There is a lateral pull on the swinging part of the towing-cable due to divergence (of about 3°) of line of pull of tow-line from line of travel of cable; but this pull is also downward. Where a clutch or some metallic attachment has to pass the roller (the said clutch at the same time embracing the cable), there will be danger of derailment, except the pulley be made so as to positively bar the cable into the path provided for it; such barring involves use of guard-arms, against which the clutch inevitably strikes.

Of M. Maurice Levy's devices for hitching his tow-line to the cable, M. le Chatelier says: "At short distances apart clutches [shackles] are mounted on the cable, and invariably in position, and these clutches [shackles] carry each a ring to which the tow-rope is fastened by a sort of slip-knot which can be loosened by drawing upon a small cord extending to the boat." M. le Chatelier calls this "a very ingenious and simple way." It is simple enough, but not very ingenious. In order to make attachment of a boat in this way a stopping of the cable has been (thus far) found necessary; as one might reasonably expect it would be. With this rig all easing up or snubbing must be done by some contrivance on the boat, and M. Levy provided no such contrivance, or none is mentioned in any description of his plant that I have seen. Nor is any such contrivance practicably applicable in such service as that contemplated. M. Levy's hitching-on contrivance is, in effect, precisely that suggested by Peter Cooper, the original patentee of driven-cable-towing in 1820. We need say no more of it than simply this: "It won't work."

M. Oriolle's clutch and combined spring-capstan rig is but little, if at all, more applicable to actual service. One may easily say, as M. le Chatelier does: "When the boat is to be attached an attendant puts a clutch upon the cable and fixes the tow-rope to one of the levers; and to the other lever attaches a cord," etc.; and to assume that the tow-rope is then rolled around the spring-capstan, which, offering a continually increasing resistance, duly communicates the cable motion to the boat. But to man-handle a clutch, "composed of an iron box having a lug to which a lever with two arms is attached," and to fix this on the cable, and attach to said arms respectively a cord (one of which is the tow-line), all while the cable is traveling along at the rate of 220 ft. per minute, is an altogether different affair.

The attendant would need to bear a hand very briskly in order to do this fixing inside of one minute, and he would need to do it inside of a minute, because otherwise his clutch would (by the progress of the cable) be brought foul of a cable-carrying roller or pulley. These rollers would be not *more* than 220 ft. apart.

We are not advised as to how the attendant would keep his position with regard to the moving cable while fixing his clutch.

The cable-towing plant of Troll & Mercier, patented in France, November, 1862, has a sufficiently ingenious device in shape of a cable roller, affording safeguard against derailment of cable, but my device (provided for use in case my perfectly plain, round-headed, channeled roller is, in certain situations, not a sufficiently positive guard against derailment) is a much less complicated and less costly piece of mechanism.

Troll & Mercier neither show nor describe any hitching arrangement beyond a simple bending of the tow-line onto the towing-cable. They simply bend on, just as Mr. Cooper simply hooked on, to a ring lashed upon his towing-cable.

M. Oriolle purposes preventing the winding of his tow-line upon the cable, which would result from the spin of the cable (were the line bent on the cable, as Troll & Mercier purposed doing) by an arrangement whereby one of three rings, encircling his cable, is pressed upward and the other two rings drawn downward, with the effect of getting a grip on the cable through opposing stress of the several rings, all free (except for friction of the body of the clutch containing them) to turn with the spin of the cable. The part of the clutch which (through pull of the tow-line) throws the middle ring upward, as aforesaid, is provided with a roller upon which said middle ring turns. The main body of the clutch bears upon the two outer and downwardly-drawn rings which revolve within said body. The mechanism by means of which the rings are made to embrace the cable is not shown in your fig. 1; but, in view of the complicated nature of the clutch device as a whole, we must conclude that the putting of the clutch-rigging upon the cable would occupy the attendant aforesaid considerably more than one minute, even were the cable at rest and were he provided with a stable footing while at work.

I avoid the winding of my tow-line upon my cable by using a cable which does not spin. The Lang cable (composed of strands, the lay of which in the cable is with [not opposed to] the lay of the wires composing the strands respectively) has very little tendency to spin under tension, and would serve admirably for a towing-cable. Because of its proved lasting quality I have purposed using it in my towing-plant. But I have now in view a cable in which there is absolutely *no* spin, which (if it proves equal to its promise in the matter of durability) I shall recommend as preferable to the Lang cable, good as that is.

I do not see that the Oriolle towing-plant is, as a whole, any more thoroughly applicable to canal towing service than is the Levy plant. Neither of these rigs has a practically applicable "grip," and without that all the rest is of but little use.

Each of several inventors in this country has patented a grip (intended for use in towing by means of elevated cable), which is fully as applicable to the service in question as is the Oriolle grip clutch. One grip, devised for use with an endless *bar-chain* towing apparatus, is very ingeniously contrived, and while it is not applicable to service with a cable traveling in simple rollers (because it demands for itself an uninterrupted line of travel), it may be readily adapted to the service of easing up a tow-line in case of sudden and unexpectedly severe strains, or surges, coming upon it, and I intend using something of the sort for the service just mentioned. Any properly applied, screw-adjusted, rope-nipper will suffice for this service. Simplicity is the essential feature in contrivances of this sort. And, in this connection, a final word about the hitching-on arrangement in canal towing by driven cable: The grip or clutch (or whatever it may be, whereby the tow-line is to take hold upon the cable) will, of necessity, be adjustable by one motion of the boatman, or practically that. It will be detachable by means of a pull on a line made fast on the boat. It will have no arms nor levers projecting from it; this because arms, etc., would speedily come to grief in banging against rollers, even if they did not at once tangle themselves with the first rollers encountered, and because when the grip is detached (by pull from boat, as aforesaid) it will drop into the canal if the towing cable travels (as it should) over and along the waterway of the canal; and we do not want in such case a grip which would be also a grapnel, and finally the grip will not be of metal, nor of any material which would render it unmasticable by the cable and rollers, in event of a foul of any sort.

My grip is a simple loop of braided cord, which, were it to get fouled on the cable, would be stripped into shoestrings by the cable without the slightest detriment to the towing-plant. The grip will cost perhaps 10 cents, not more. Every boat will carry several spare grip-loops. I calculate that a grip-loop will last in service about a week. When worn, replace. Keep a spare tow-line always ready for service. It will now and again be wanted for use as a breast-line, for steering purposes.

Those who care to examine the detail of my towing plant may send for copy of Patent No. 371,680, dated October 18, 1887. I have published a treatise on Cable Towing in Canals, incidentally discussing driven-cable traction generally. This work affords a quite comprehensive view of the subject indicated by the title.

Sharpsville, Pa. J. M. GOODWIN.

A GREAT ENGLISH CRUISER.

(From the London *Engineer*.)

THE first-class twin-screw cruiser *Blake*, which was successfully launched at Chatham recently, is, beyond a peradventure, the most formidable of the "grayhound" series afloat in the British Navy—or, rather, will be so when completed. Mr. White, the Director of Naval Construction, has jumped far ahead of all designs of a similar character now being brought forward, in his plans for the new vessel. While the Italian *Piemonte* has only a displacement of 2,500 tons, although the speed is almost equivalent to that of the *Blake*, the latter possesses no less than 9,000 tons displacement, with the tremendous dimensions of 375 ft. in length by 55 ft. beam, and a draft of 25 ft. 9 in., thus affording a steady platform upon which her guns could be worked without intermission, while lighter cruisers were pitching and tossing around her, and only able to reply with an occasional shot. The *Blake* is 75 ft. longer than either of the belted cruisers. She is constructed of steel throughout, and has a powerfully armored turtle-back steel deck covering the magazines, torpedo-rooms, engines, and boilers, a special protection for the tops of the cylinders being provided in dome-shaped steel shields, which rise above the protective deck. They are from 6 in. to 8 in. in thickness, the protective deck having a maximum thickness of 6 in. in the center, diminishing to 4 in. and 2 in. at the extremities of the vessel. The frame is particularly stout, and so combined with the steel-armored deck as to afford facilities for ramming; 9,000 tons, projected at a speed of 22 knots against an enemy's vessel, would represent an impact that would be irresistible. A large space has been allotted for fuel. No less than 1,500 tons of coal can be carried, which will suffice for a distance of 15,000 knots at 10-knot speed, or 3,000 knots at the ordinary sea speed of 20 knots, expected to be attained. We should have mentioned that the conning-tower is thickly plated with steel, and that special deflective shields will be fitted to the guns, to rotate with them, and entirely cover the breech and gun detachment. It is considered that the 6-in. steel deck-plating will divert a projectile quite as effectually as 12-in. plating of a vertical nature. This, however, remains to be proved. The experiments on the *Resistance* early in the year were scarcely favorable in their results to the importance of turtle decks. The *Blake* has a double bottom, in this respect a vast improvement upon the *Piemonte*.

The machinery, which is being made by Maudslay & Company, will consist of two independent sets of triple-expansion engines of the vertical type, guaranteed to develop 20,000 H. P. with forced draft, and, by means of twin screws, to drive the ship at a maximum rate of 22 knots; with natural draft the horse-power is to be 13,000, and speed 20 knots. As plenty of space has been given to engines and boilers, and the forced draft is not to exceed an air pressure of 2 in. of water, it is probable that the expectations of the manufacturers will be fulfilled.

The *Blake's* armament, as originally designed, was to be two 9.2-in. 22-ton breech-loading steel guns, and ten 6-in. 5-ton 100-pounder quick-firing Armstrong steel guns, eighteen 3-pounder quick-firers, and four torpedo-tubes. But it is doubtful now whether the 6-in. quick-firers will be placed in her, as the size, weight, and length of their projectiles makes them unhandy. The charge and projectile have to be handled separately, and this, to a great extent, neutralizes their value as quick-firers. Moreover, the sealing of the windage in such cases becomes a difficulty, and this has hitherto been found to be insuperable. It is all-important for a quick-firer that the powder-gas should all act toward the muzzle of the gun. Hence, it is probable that the 4.7-in. quick-firing Armstrong steel gun having a projectile of 45 lbs. weight and powder charge made up into a regular cartridge, weighing about 70 lbs., already approved for service both in the Army and Navy, will be employed for the armament of the *Blake*. Four of these guns were mounted in the *Teutonic* at the recent Naval review, and attracted so particularly the attention of the German Emperor that he ordered several of them upon the spot. The 45-pounder has a piercing power up to 12 in. or 15 in. of armor-plate, and 12 shots can be successfully fired per minute from it, only two men being required to work the gun. The 9.2-in. steel breech-loading gun is the most satisfactory of all heavy guns which have been built for some years. It has no tendency to "droop" at the muzzle, has a penetration power up to 18.8 in. of armor-plate, and throws a projectile of 380 lbs. weight at a muzzle velocity of 2,065 foot-seconds. We only regret that any heavier guns should have been constructed; they are perfectly unnecessary.

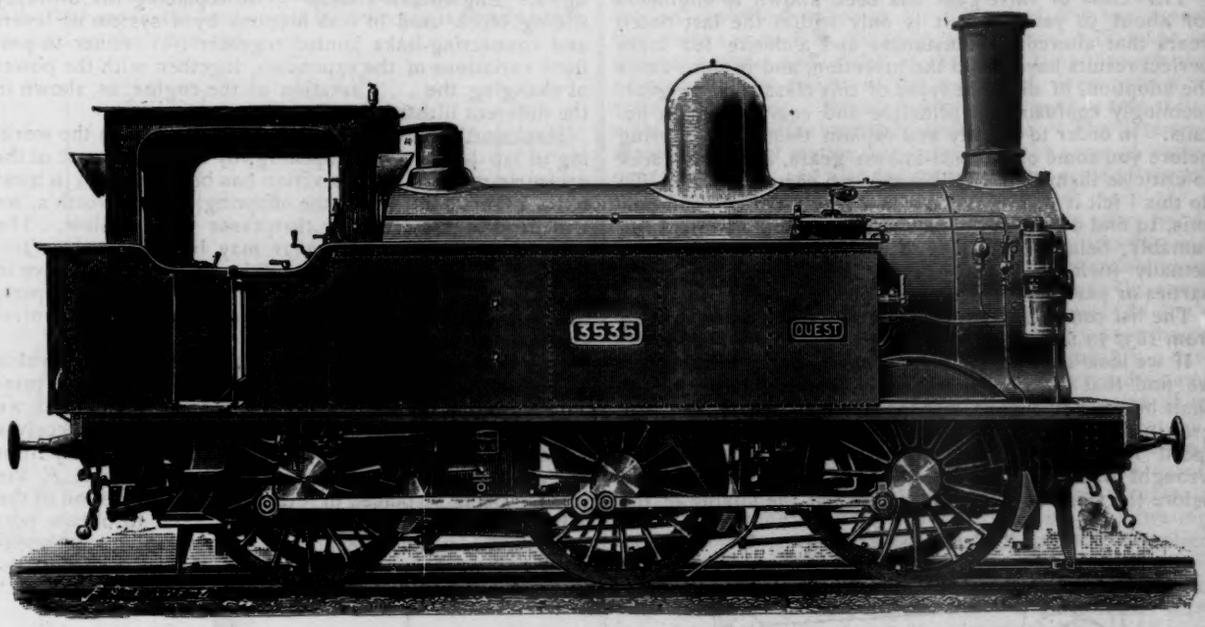
The *Blake* will cost $1,840,000. She will be employed as a swift cruiser to protect our commerce in the Atlantic

and in Australasian waters, and her speed will enable her to keep pace with any liner afloat. Her sister ship, the *Blenheim*, is now under construction at Blackwall, the Thames Ironworks Company having contracted to deliver her shortly.

A FRENCH TANK LOCOMOTIVE.

(From the London *Engineering*.)

THE tank locomotive for the Western Railroad of France, of which we give an engraving herewith, is one which was shown at the Paris Exhibition by the builders, the Compagnie de Fives-Lille. The engine is of a type which the Western Railroad Company has used for some years for working local traffic on lines with steep gradients, and it is, as will be seen, a six-coupled tank locomotive with inside cylinders and valve gear. Engines of this type are in use working passenger traffic on the line from Paris to St. Germain, *via* Pecq, which has a gradient of 35 mm. per meter (3½ per cent.) on the line from Paris to St. Germain



PASSENGER TANK LOCOMOTIVE, WESTERN RAILROAD OF FRANCE.

via Marly, where there are numerous gradients of 1 in 66.6; and on that from Paris—St. Lazare to Paris—Champ de Mars *via* Moulineaux, on which there are frequent inclines of 1 in 100.

As regards the line from Paris to St. Germain *via* Pecq, we may mention that from the date of the suppression of the atmospheric system of working up to 1886, the trains were hauled from Paris to Pecq by four-coupled engines, while the part of the train destined for St. Germain was then taken on from Pecq by powerful six-coupled tank engines with wheels 4 ft. 3 in. in diameter. This change of engines at Pecq occupied five minutes, and moreover led to frequent delays, and this, together with other considerations—among them the desirability of running some trains between the terminal stations without intermediate stops—led to the construction of the engines now illustrated, suitable for working trains over the whole route. The chief dimensions of this type of engine are as follows:

Diameter of cylinder	1 ft.	4.9	in.
Stroke " "	1 "	11.6	"
Distance apart of centers of cylinders	2 "	1.6	"
Length of connecting-rods between centers	5 "	8.8	"
Diameter of wheels	5 "	0.6	"
Distance between centers of leading and driving-wheels	7 "	0.6	"
Distance between centers of driving and trailing-wheels	7 "	6.5	"
Total wheel base	14 "	7.1	"
Distance apart of frames	4 "	1.1	"
Total length of engine over buffers	28 "	0	"
Diameter of boiler barrel (mean)	4 "	0	"
Length " " "	10 "	2	"
Length of inside fire-box	4 ft.	1.5	in.
Width " " "	3 "	4.2	"
Height of fire-box crown above grate	4 "	11	"
Number of tubes	203		
Diameter of tubes outside	1.77 in.		
Length of tubes	10 ft.	6 in.	
Working pressure	142 lbs.		
Heating surface: Fire-box	81.8 sq.	ft.	
" " Tubes	989.2 "		
Total	1071.0 sq.	ft.	
Grate area	14.7 "		

The tanks hold 880 galls. of water, and the coal bunkers 2,500 lbs. of coal. The total weight of the engine in working order is 41.5 tons, of which 13.5 tons are on the leading wheels, 13.8 tons on the main driving-wheels, and 14.2 tons on the trailing-wheels.

The boiler has a raised fire-box casing and large dome near the center of the length of the barrel. The boiler shell is of iron, the fire-box of copper (as is also the smoke-box tube plate), and the tubes of brass. The grate is slightly inclined, and the front portion is made to drop.

As in many of the locomotives belonging to the same company, the boiler is enclosed in a sheet-iron air casing which extends from end to end over the smoke-box, and gives the engine the appearance of having a flush-topped boiler. Within this casing the sand-boxes are arranged. The boiler is fed by two No. 9 Friedman injectors, one of the delivery pipes having a branch pipe and cock to which a rubber tube with hose can be attached for the purpose of watering the coal in the bunker. The blast-nozzle is not variable, and is 5.1 in. in diameter.

The frame-plates are of steel, and are 1 in. thick. The buffer-beams are of iron, and the front one is hinged to the frames at its lower edge, so as to give easy access to the front cylinder covers. The cross-connections between the frames are fewer and less rigid than is usual in English practice in engines of a similar type. Thus the only cross-connection between the cylinders and the attachments of the rear foot-plate is that afforded by the motion-plate.

The axle-box guides are of wrought-iron, and each is fitted on one side with an adjusting piece, secured by bolts. The springs for the leading and driving axles are above the axle-boxes, while those for the trailing axle are below, but are arranged so that the end links are in tension. The tires and axles are of cast steel, and the crank-shaft has hooped cranks and a bolt through each crank-pin.

The cylinders are inclined at an angle of 1 in 8½, and are placed close together with the valve faces below, so that the valves are readily accessible. The valve-motion is of the Stephenson type, with expansion links of the box pattern, and to accommodate the position of the valves the

motion is transmitted to the latter through rocking levers, as shown in fig. 1.

The pistons are of the Swedish pattern, and are of steel with cast-iron rings. The guide-bars are single and are embraced by the cross-heads, which are fitted with gun-metal wearing faces. The piston-rod packing is metallic, of the Duterne pattern. The eccentric straps are of gun-metal, and the reversing-gear is of the screw type. The coupling-rods are of steel, and their ends are fitted with solid bushes.

The water is carried in a pair of wing-tanks, and the coal-bunker extends across the rear of the foot-plate, as shown. The engine is provided with a hand-brake acting on all the wheels, and it is also fitted with the Westinghouse brake, the air cylinder for which is arranged beneath the foot-plate.

RADIAL VALVE GEARS.

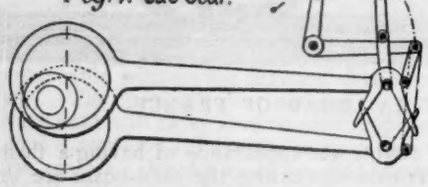
(Paper read before the Hull Institute of Engineers & Naval Architects, by J. R. Smith, Engineer.)

THIS class of valve gear has been known to engineers for about 50 years, but it is only within the last dozen years that altered circumstances and a desire for more perfect results have led to the invention, and in some cases the adoption, of different types of this class of valve gear, seemingly confusing in principle and complicated in details. In order to classify and explain them we will bring before you some of the best-known gears, and would seek to criticise them impartially and in no partisan spirit. To do this I felt it was necessary to consult the original patents, to find out what the patentee really claimed, he, presumably, being at the time a better judge of what was actually included in his patent than either interested parties or partisan advocates.

The list consulted includes 30 patents, the dates varying from 1837 to 1888.

If we look back at the early history of the slide-valve, we find that the single eccentric, working loose on the shaft between two stops, was the commonly-used reversing gear in slow-going land and marine engines, till the higher speed locomotive engine led to the double-gab motion wrought with two eccentrics, fig. 1. It was many years before the spirit of invention suggested the joining of the

Fig. 1. Cab Gear.

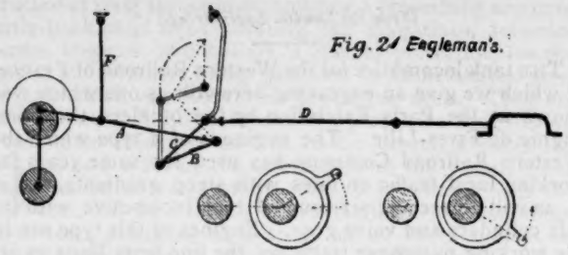


two gabs together, thus leading to Stephenson's slot-link motion. This at once displaced all other reversing motions, the only competitor being the single fixed eccentric, reversed by the spiral sleeve. Mr. Horn, patentee of the condenser wooden ferrules, had a number of engines fitted with this gear about 1860, but you could not "link up" with it, as in the link motion, unless by stopping the engine and piecing on to the driver. Thompson, of Dundee, has revived this style in the small engines made by him.

But inventors were not at rest even after the link motion had displaced the other gears, for we find Punshon in 1839, and Mellor and Hawthorne prior to 1844, working the slide-valve off the connecting-rod. Hawthorne's plan, which was the most complete, is illustrated in Bourne's "Steam Engine," 1846 edition, but it was too complicated to compete with the link motion.

The travel of the slide-valve wrought by a direct link motion is equal to the throw of the eccentric, which by one direct movement causes the valve to travel lap + lead + port opening; but in the year 1859 two clever patents were taken out in this country to do away with the link-motion valve gear, and to accomplish the above motion on a different principle and by different gear; the first by that able and ingenious engineer, J. W. Hackworth, in his Patent No. 2,448, of 1859, the other a French invention showing great ingenuity, but very complicated, by Englemann, of Mulhouse, in his Patent No. 2,864, of 1859. The latter shows one plan of his gear with a single eccentric, fixed opposite the crank with the eccentric-rod, vibrating on a Fink link. Another arrangement was to work off a direct connection to connecting-rod, with compensating levers, but both go on the principle of working expansion and reversion, by shifting not the eccentrics, but

Fig. 2. Engleman's.



the eccentric strap about 30° on each side of neutral line, fig. 2. Englemann claims "The replacing the ordinary sliding block used in link motions by a system of levers and connecting-links jointed together . . . either to produce variations of the expansion, together with the power of changing the . . . rotation of the engine, as shown in the different illustrations."

Hackworth, on the other hand, did away with the working of lap + lead + port opening, by one movement of the eccentric-rod, and as this action has been adopted in most of the other radial gears, the offspring of Hackworth's, we will explain it more fully than those which follow. The principle of Hackworth's gear may be expressed as follows: "In fig. 3, as the point *D* is constrained to move in paths *A*, *B*, or *C*, so the point *E* moves in three ellipses, the elliptical paths giving motion to the valve-rod in neutral gear, ahead gear, or astern gear."

At this stage I would draw your attention to fig. 4, which may be called Hackworth's complex gear, and the principle of which is illustrated in his specification. If we make *B z* horizontal it is evident that the point *E* receives no motion from the traverse of the point *D*, but only from the vertical throw of the eccentric through point *F*, the point *V* being so placed in lever *f d* that the motion of the valve would be equal to lap + lead. But to obtain port opening (or, strictly speaking, the "remaining port opening," and so throughout this paper), the point *D* must re-

Fig 4.

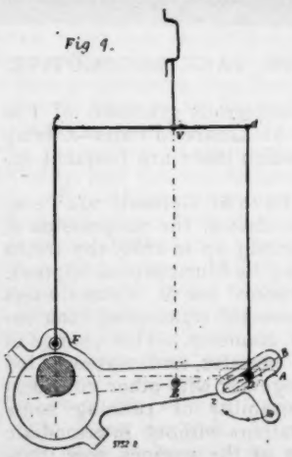


Fig 3 Hackworth's N°1

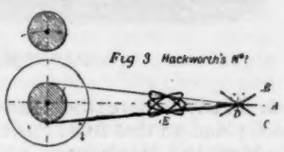
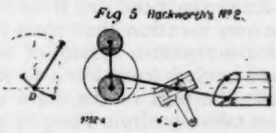


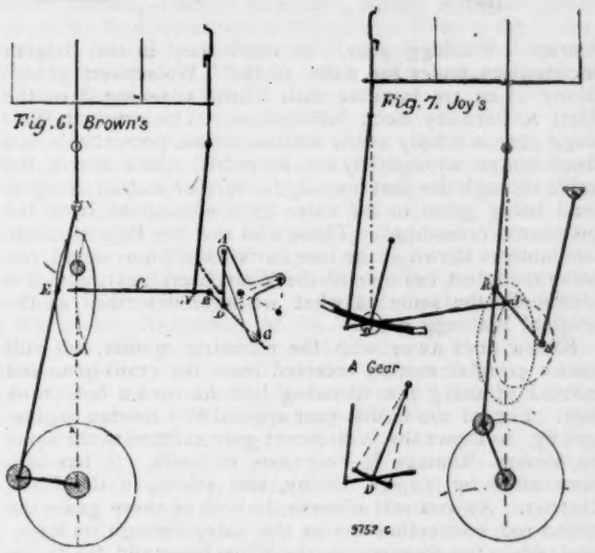
Fig 5 Hackworth's N°2.



ceive a motion which will cause it to rise and fall; this is got by angling *B z*, as shown in the engraving, and so we see that in Hackworth's gear the travel of the valve is produced by the component motion of the vertical travel of rods *F f* and *D d*. Let us now eliminate the three rods *F f*, *f d*, *d D*, and connect the valve-rod direct to the eccentric-rod by one rod *V E*, and we have Hackworth's gear as patented by him in all its simplicity, an expansion reversible valve gear not only having fewer working parts than Englemann's or other previous gears, but also as few as any other gear since invented to attain the same ends.

In the gear wherein the fulcrum is at the end of the eccentric-rod, which is a lever of the second order, as he explains and illustrates it, wrought by a radius-rod suspended from the valve-rod side of eccentric-rod, see fig. 3, *B* gear, which is the first example of a radius-rod applied to a lever of the second order, Hackworth claims "The arrangement and combination of the machinery for deducing two motions from one eccentric, one motion for working the lap and lead of the valve, and the other at right angles with this, whereby I obtain variable expansion and reverse motion. And other 10 claims of arrangement and combination of machinery as set forth," etc.

Hackworth took out a patent for his second gear in No. 4,246, of 1876, in which he makes the eccentric-rod a lever of the first order, by altering the position of the fulcrum *D*, and working the valve-rod off the end of the lever; this gives a better elliptical motion to the point *E*, and enables you to get a given travel of valve with a less throw of eccentric, and makes the valve decidedly quicker in its action than in No. 1 gear. But with these benefits it has this serious disadvantage, that while in the first gear the load on fulcrum-pin *D* is never much over the load on the valve-rod, in this his second gear with eccentric-rod a lever of the first order, the load on the fulcrum-pin is nearly twice the load on the valve-rod.



He states that the two right-angled movements cause the valve to open quickly on turning the center, which is immediately followed with partial suspension of motion, the two actions neutralizing one another, and claims, "Increased expansion of steam is obtained by connecting the valve-rod to the extreme end of the eccentric-rod." Fig. 5 illustrates this second gear, in which you will observe the difference of the elliptical path compared with fig. 3. In both these gears the point *D* is on the same plane as the center of the shaft when the eccentric is at the top or bottom centers, no matter whether in neutral, ahead, or astern positions, so it follows: 1. That this gear gives constant lead top and bottom for all degrees of expansion; also 2. That we have equal port opening top and bottom; and 3. That the slow and quick periods are extended longer than if the path of *E* had been a circle instead of elliptical. One objectionable feature in Hackworth's gear (more noticeable in No. 1 gear) is that it necessitates a long angular traverse motion to give a short vertical motion.

The egg-shaped oval described by a point in the complete sweep of the connecting-rod, during a full revolution, would be a tempting project, if it could be made to work Hackworth's principle of expansion and reversion instead of an eccentric, but it requires no great perception to see that whenever we attach direct to the connecting-rod we introduce an error, owing to the major axis of the oval being a straight line, while the radius of the vibrating lever is an arc of a circle (see fig. 6), so that unless we make the vibrating lever infinitely long, the fulcrum point will traverse unequally on each side of the neutral point; so all gears working off the connecting-rod must have some compensating means to correct this evil, and this compensation is the basis of most of the patents of connecting-rod radial gear.

Brown, of Switzerland, in his Patent No. 5,175, of 1878, was the first to work the Hackworth class of gear off the connecting-rod, and this he did by connecting direct on to the rod, but compensating by his compound radius bars *A D*, *B G*, fig. 6. He made a great many locomotives for Swiss, German, and other railways; usually these were fitted with a rocker between the piston-rod and the connecting-rod, but in our illustration we have shown this gear applied to a marine engine, and for simplicity we have shown the valve-rod attachment as placed by Brown to suit his rocker engines; but this being done away in our application, the valve-rod would require to be bent to dotted lines, and the vibrating lever made one of the first order. It will be seen that the rod *C*, attached direct to the connecting-rod at the point *E*, swings from point *A* by connection with the radius-rod at the point *D*, causing the point *B* to describe an angular line, slightly curved, and gives motion to the valve-rod by means of the elliptical motion described by point *V*. The point *B* is the important point to watch in this gear, and the rod *B G*, when in motion, swivels and slides at the same time through the center *G*. The radius of the rocker, *L*, even assists to equalize this gear. Brown describes his gear as one of the class known as Hackworth's, and claims "The arrangement of parallel motion for correcting the error of valve-gear radius-rod, and also for correcting the error produced by the curved path of the vibrating lever."

Joy, in his Patent No. 929, of 1879, on the other hand, does not connect his vibrating level to the connecting-rod direct, but ingeniously introduces a compensation lever *R S*, fig. 7, and connects the vibrating lever to the same at the point *J*, which is the most interesting point in Joy's gear, for while the point *R* describes an oval whose major axis is a vertical straight line, the point *J* describes a flattened ellipse, the major axis of which is the versed sine of the vibrating lever, thus causing the fulcrum point *D* to have a motion equal and symmetrical.

Joy utilized Hackworth's No. 2 gear, but with the sliding path altered to a curve equal to the radius of the valve-rod; but he also described, and in some cases uses, a radius-rod swinging from the valve side of the vibrating lever, and which is the first example of a radius-rod applied to a lever of the first order (fig. 7).

Advocates of the link-motion and single-eccentric gear take exception to Joy's curved slot "sliding-block" surface, but it compares favorably with single-eccentric gear (as Marshall's) or link-motion with two eccentrics, where the rubbing surfaces of Joy's sliding block, compared with the eccentric surfaces of the two gears named, would be per revolution as 1 : 3 and 1 : 5.

This is the best-known radial gear, and over 1,000 locomotives working in this and other countries, as well as 35 war vessels and over 100 merchant steamers, have been up to date fitted with it, although marine engineers, while conceding that it is one of the best gears, have fought rather shy of it, thinking it rather expensive to make.

Joy claims "The use, for the purpose hereinbefore mentioned, of a lever coupled and having its motion governed in the manner described in specification."

Further on, in 1879, Bremme took out his Patent No. 2,037, for "Improvement in Steam and other Steering

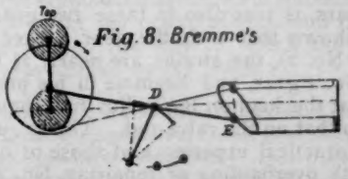


Fig. 8. Bremme's

Gears," in which he used Hackworth's second gear, but with the fulcrum point swinging on a radius-rod, this being the fourth example of the use of the radius-rod, and the second example of its application to a lever of the first order, but this he applied the opposite way to that

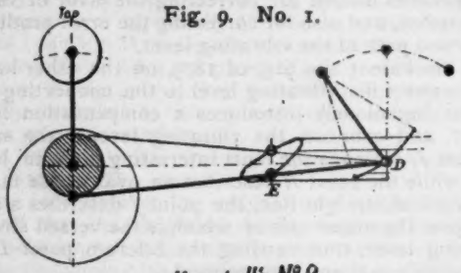
shown by Hackworth in 1859, by Brown in 1878, and Joy in 1879, in their respective gears. Bremme's gear, copied from his specification, is shown in fig. 8, and he claims "Sixthly, reversing gear constructed and operating as substantially set forth."

From the illustration you will see the excessive difference between the port opening top and bottom in this gear, to remedy which Bremme made no provision in his patent.

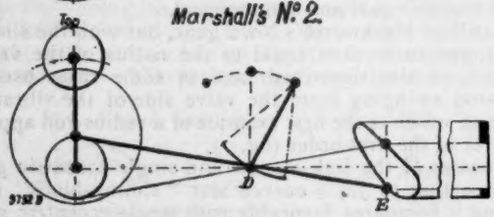
As Bremme's patent rights and rather bold claims have been much advertised and criticised of late, the Author would state his conviction, that while Bremme's specification was the first to show the radius-rod attached to Hackworth's No. 2 gear wrought by an eccentric, yet he was not the inventor of the radius-rod attachment (Hackworth's 1859 gear had it), neither was he the first to apply it to a lever of the first order, for Joy had included this, so that Bremme is tied down to his own design of gear "constructed and operating as substantially set forth," but which is never made; at least in the Author's experience he has never seen one.

In 1879 and 1880 Marshall took out his patents for the gears which are now known by his name; these two gears introduce us to the radius-rod gears as now usually made; the first one, fig. 9, was really illustrated in Hackworth's 1859 specification, and Marshall honestly acknowledges this to be a modification of Hackworth's, but finding out the inequality of port opening due to the mean inclination of the curved path being less under the neutral point than

Fig. 9. No. 1.



Marshall's N° 2.



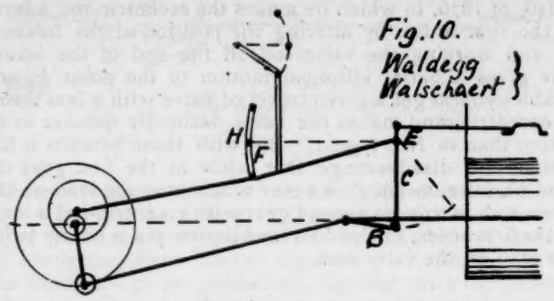
above it (see difference in fig. 9), thus making the valve travel unequal, he corrected the same by means of an extra port opening. This also applies to the No. 2 gear. These two radius-rod gears, as mechanical arrangements, have the advantage over the two original sliding-block gears, working with circular surfaces instead of sliding surfaces, the former requiring less surface per unit of load and being easier to adjust, although the extraordinary wear got by Joy out of his sliding blocks has revived, in an example yet to be given, the old sliding-block system of Hackworth. On the other hand, considered as steam distributors, Hackworth's has the advantage of equal port openings at the top and bottom of the valve, while the radius-rod system has the advantage of equal cut-off top and bottom.

What we stated, when comparing Hackworth's No. 1 and No. 2 gears, is true also in these two gears, and Mr. Milton has shown that with the gear a lever of the first order (fig. 9, No. 2), the strains are nearly 2¼ times more than in the No. 1 gear, and Bremme in his printed circulars states that the load on the radius-rod should be reckoned 2¼ times that on the valve-rod. This is quite in keeping with the practical experience of those of us who have had to do with overhauling or repairing No. 2 gear, and Mr. Marshall himself states, "That the strains in working (No. 2 gear) were so great that the advantages were more than counterbalanced by the risks attending its adoption." Of course extra large surfaces and the use of piston-valves would help, but we can never get over the fact of the greatly-increased strain the one gear has compared with the other.

Marshall, who fits this style of gears almost exclusively, has done more than any other engineer to bring them into repute; he claims, in his 1879 patent, "The combination of mechanism constituting the valve gearing, consisting of eccentric and strap, having a valve lever suspended from an arm on reversing shaft by a radius-rod, arranged and operating substantially as shown and described; also the use of dissimilar ended valves of the common slide, the Trick slide, or cylindrical construction."

In Kitson's Patent No. 4,612, of 1879, we are introduced to another class of valve gear, a modification of the well-

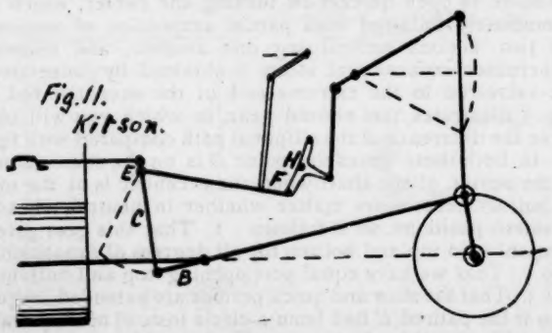
Fig. 10.
Waldegg
Walschaert



known "Waldegg gear," so much used in the Belgian locomotives under the name of the "Walschaert gear." Many of us are familiar with Kitson's, seeing it on the Hull & Barnsley dock locomotives. The original Waldegg gear is simply a link motion whose neutral axis is a fixed center, wrought by one eccentric, which moves the valve through the port opening, a further motion of lap + lead being given to the valve by a connection from the piston-rod cross-head. Those who saw the Belgian State locomotives shown at the late Paris Exhibition would observe the latest example of the Walschaert gear, and it is identically the same as what we have described as the original Waldegg gear.

Kitson does away with the eccentric motion, but still uses a circular motion received from the crank-pin, and instead of using the vibrating link he uses a bell-crank link. Fig. 11 shows this gear applied to a marine engine, and fig. 10 shows the Walschaert gear as fitted to the same by Messrs. Ramage & Ferguson, of Leith. It has also been fitted by Napier, Denny, and others, in the Clyde District. As you will observe, in both of these gears the piston-rod connection moves the valve through its lap + lead, while the eccentric in the Walschaert and the throw from the crank in the Kitson gives the port opening. The method for accomplishing expansion and reversion is by

Fig. 11.
Kitson.



sliding valve-rod attachment to block *F* across the link *H*, as in the usual link motion.

Zeuner has pointed out in connection with the Waldegg gear that, with the exception of the constant leads, it is no better than a well-designed link motion for steam distribution. The angling of the rods, however, in the Walschaert application to marine engines has a beneficial effect on the motion of the valve, giving equal or unequal cut-offs. Kitson claims "The means above described for obtaining the motion for working the slide-valves of motive-power engines from the cross-head and cranks of such engines."

(TO BE CONTINUED.)

WATER-TUBE BOILERS.

(Abstract of paper read before the Institution of Civil Engineers, by W. I. Thornycroft.)

WATER-TUBE boilers are those in which the water to be evaporated is contained within the tubes which form the heating-surface. In 1878 Mr. Flannery, in a paper contributed to the Institution, showed what progress had been made up to that date with this kind of boiler at sea. That communication, and the discussion which followed, proved that although considerable saving of fuel had been obtained with them, water-tube boilers as then made were unsuitable, because the tubes forming the heating-surface were burned, owing to insufficient circulation. The Author, therefore, commenced by discussing the kinds of circulation in various forms of tubulous boilers, arriving at the conclusion that circulation, in order to be perfect, must be systematic, under which condition a smaller amount of water could be successfully used and the weight of this element thereby reduced. By circulation, he intended to convey the idea of motion of the water contained in a steam generator, from the upper surface of the liquid down to the lower part of the generator, and returning again to the upper surface. Motion of water, simply from the point where the feed-water was admitted to a point in the boiler where it became steam, he wished to hold distinct from the idea of circulation. Having thus defined the term, the Author divided all boilers into classes, depending on the manner in which circulation took place. The first type dealt with was described as the oldest and simplest form of boiler, in which circulation at the outset depended upon small variations of density in its different parts. The action might be energetic when boiling took place, but was wanting in order, being struggling and confused in character, and nowhere acquiring high velocity. The circulation of the earliest water-tube boilers was of this nature. The Author then described the boilers of Mr. Perkins, Mr. Herreshoff, M. du Temple, and Mr. Matheson; and also gave an account of the Field tube. The boilers of the *Peace* and of the *Propontis* were compared, and the most suitable diameter and length of tube were discussed. The Author attributed the failure of the upper ends of the tubes of the *Propontis* to their being of such large diameter that, instead of steam and water passing over in foam, steam alone left the tubes, and all impurities brought in with the feed-water gradually accumulated in the upper part of the tubes, and ultimately led to their destruction. He thought it possible that obstruction from sediment collected in this manner gave rise, at a later period, to the more serious failure of the large water chambers. He next showed that a water-tube boiler might be constructed of less material than one of the ordinary form, and that this result was partly due to the fact that a strong envelope only was required to surround the steam and water, which must necessarily be enclosed in a pressure-resisting shell. In the case of the ordinary form of boiler, there was a strong vessel containing not only the steam and water, but likewise the fire and the products of combustion. These latter, it was pointed out, were again enveloped in a second or inner shell, and thus were covered twice by material to resist the whole pressure contained in the boiler. This was shown to be one evident cause of the great saving of material possible with the water-tube system. The reduction in weight was accompanied by greatly superior steaming power, economy of fuel, and less forcing of the fires. Lastly, the safety of the vessel and crew had been materially increased. The conditions favorable to perfect combustion, and those which tended to satisfactory absorption of the heat from gases produced, were then described, together with a boiler which the Author had designed with a view to embody the principles of circulation and of combustion which appeared to him to be the best. Lightness of structure and strength to resist internal pressure had been particularly kept in view, and the evil effects of unequal expansion had been provided for by the curved form of the tubes, which afforded practically the whole heating-surface. These tubes were shaped so as to make an arch over the fire, only allowing escape for the products of combustion by a series of narrow openings a little above the surface of the fire. In the upper portion of the arch each tube, by touching its neighbor, formed a continuous roof, and enclosed a large space above the firebars extending the whole length of the boiler. The tubes which composed the fire-box having arrived at a point near the center of the arch, altered their direction of curvature, and after meeting, turned apart again to give room for the largest vessel in the boiler. By keeping in contiguous lines they afforded a protection from the heat to this vessel. In a similar way in which the furnace was formed, two rows of tubes united to make the external casing of the boiler, at the same time constituting a flue in which numerous other tubes were placed. The ends of all these tubes were secured in three horizontal cylinders, two of which served the purpose of supplying water to the tubes. The third was a separator, from which the steam produced was taken and the overflowing water returned to the tubes. For this purpose large external tubes connected the separator to the cylinders forming the base, and between these cylinders the firebars were arranged with a firebrick bridge on either side, protecting the cylinders from excessive heat. The fire-doors were situated at one end of the tunnel or arch of tubes, and the other end was closed principally by blocks of light fire-resisting brick inclined away from the fire to add to their durability. The water-level in the boiler was best a little below the center line of the separator, in which was placed, underneath the points where the tubes entered, a shield, to guide the circulating water down to the water-surface, at the same time protecting from spray a perforated pipe, in which the steam was collected. The ends of the boiler were covered with plating, and in order to make the casing quite smoke-tight, the outer wall of tubes was also covered with light plating; but this had not to resist any great heat. The first water-tube boiler, put into a torpedo-boat by the Author's firm, afforded a very satisfactory means of comparison between the new boiler and its locomotive rival, which had been placed in a sister vessel. The result of steaming was eminently satisfactory, and the saving in fuel at equal speeds was sufficiently evident without exact experiment, the boat under natural draft being about 1 knot an hour faster than the other vessel, the full-power trials showing also a difference of 0.67 knot speed in favor of the former. Some evaporative trials were made by the Portsmouth authorities, and the results seemed to indicate that equal duty could be obtained when the proportionate quantity of water evaporated was 2.36 from the water-tube boiler to 1.00 from the locomotive boiler. After this boiler had been at work for three years, several tubes were cut out with the view to ascertain their state. They afforded a sample of tubes under varying conditions. Some were taken from the fire-box where they had been exposed to the full intensity of the heat, and some from positions in the flue where the heat was much less. Their condition was eminently satisfactory. The small amount of scale in their interior was a great contrast to the condition of water-tubes taken from the boiler of the *Propontis*, in which the circulation was not so well provided for; the thickness of the tubes had suffered no perceptible diminution. The Author then gave the results of some recent trials made by Professor Alexander Kennedy—whose report was appended to the paper—both with natural draft and with different amounts of forced draft, and a full description was given of the method of conducting them. At the most economical rate of working, the evaporation, reduced to standard, amounted to 13.4 lbs. of water per pound of fuel, and the following heat-balance showed the way in which the heat of the combustion was utilized by the boiler:

	Per cent.
Heat expended in heating and evaporating feed-water	86.8
Heat expended in raising temperature of furnace gases	10.8
Heat lost through formation of carbonic oxide	0.5
Heat lost by radiation and otherwise unaccounted for	1.9
	100.0

The very high percentage of evaporation—86.8—represented the efficiency of the boiler, and was simply equal to the ratio between the actual evaporation and that theoreti-

Fig. 2

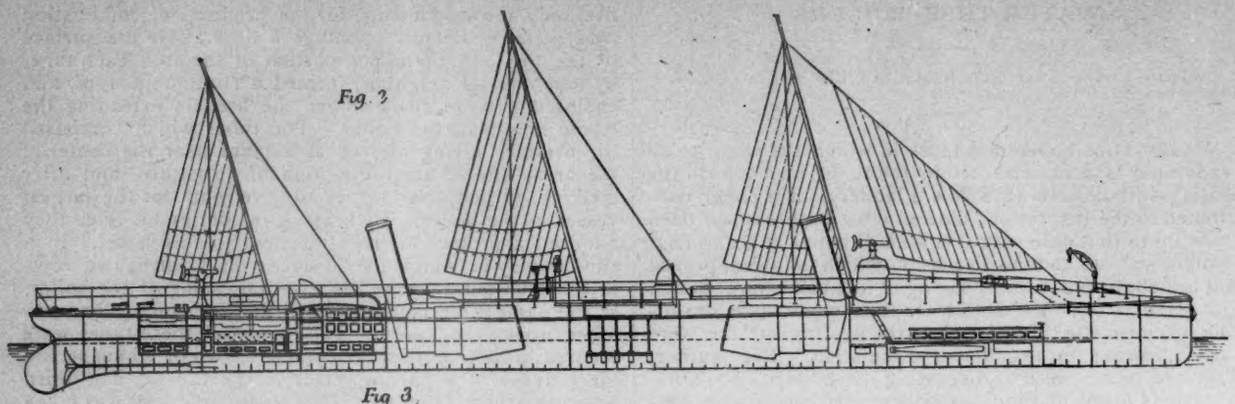


Fig 3.

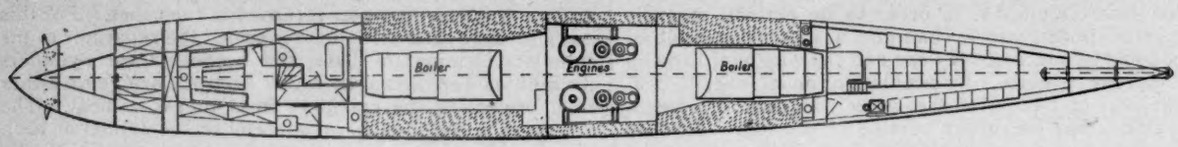


Fig 4

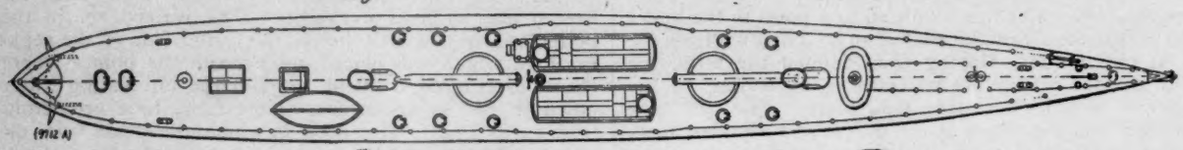


Fig. 6. Wave line at 14 Knots

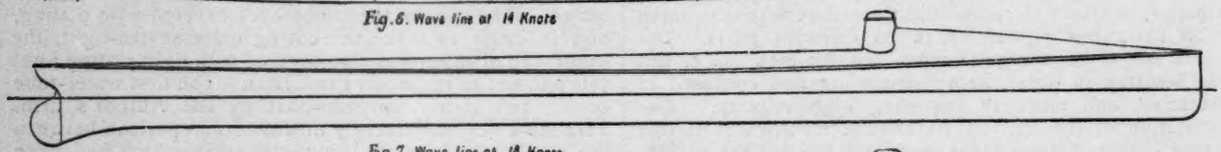


Fig. 7. Wave line at 18 Knots.

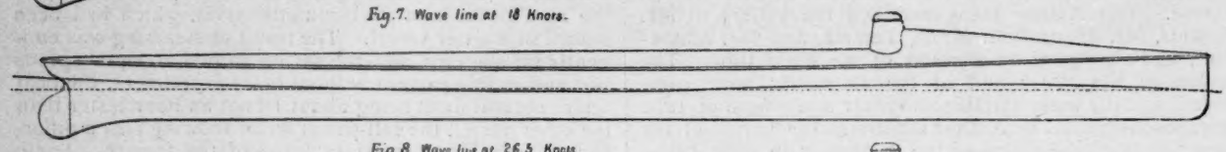
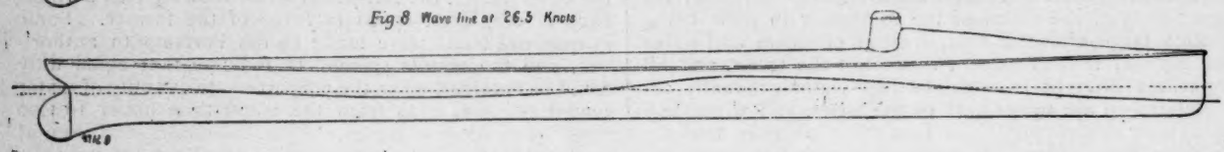


Fig. 8 Wave line at 26.5 Knots



13 Atm Boiler pressure. 0,91 Vacuum. = 13·31lbs. Fig. 5.
325 Revol.s per minute. 17" Stroke.
Dia.r Cyl.r 17" - 26" - 37"

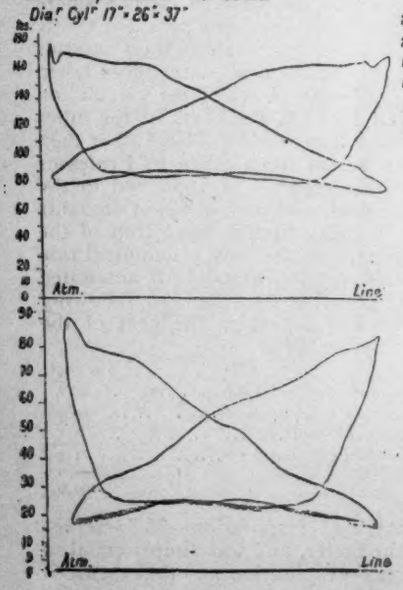
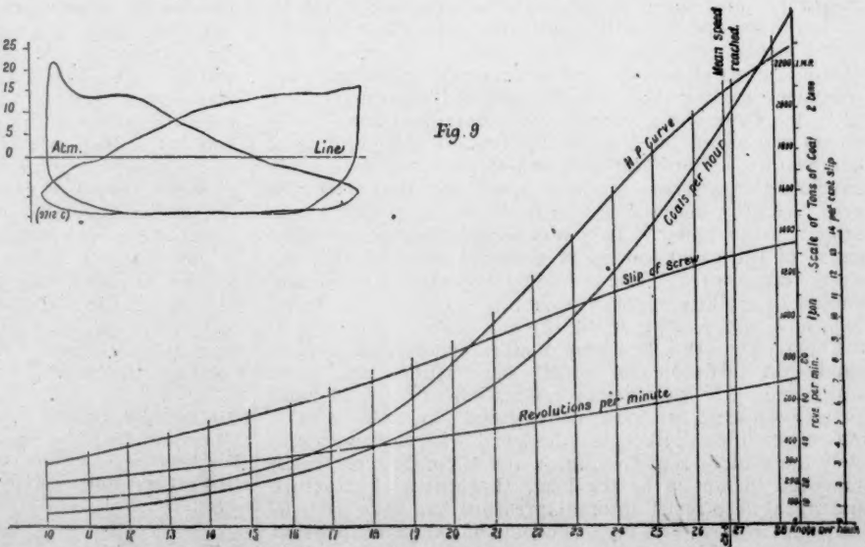


Fig. 9



cally due to the perfect combustion of the fuel, or 13.4 : 15.4. This is believed to be the highest boiler efficiency on trustworthy record.

The fact may be added to the statements in the paper that water-tube boilers are to have a test in practical working in the United States Navy.

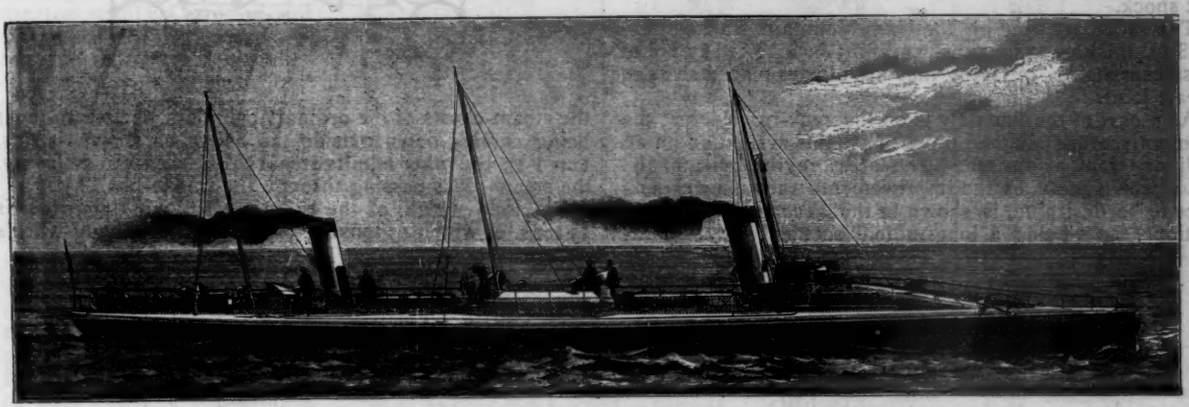
TORPEDO BOATS FOR THE ITALIAN NAVY.

(From the London *Engineering*.)

AMONG the oldest, and certainly among the most successful of the Continental builders of torpedo boats must be classed Mr. F. Schichau, of Elbing, Prussia. Mr. Schichau has not been content simply to follow in the footsteps of the two leading English builders, but he has proved a most formidable rival; and, indeed, in some cases, it must be confessed, the English builders have followed the lead of the Elbing yard.

We have at various times previously illustrated some of Mr. Schichau's boats, and we are now, through his courtesy, able to place before our readers fuller particulars of some of his most successful craft. The remarkable speed attained by these vessels renders the data especially valuable, and English naval architects and engineers will be interested in following the results obtained.

The accompanying illustrations show a twin-screw torpedo boat built by this enterprising firm. The engravings represent one of five sister vessels built to the order of the Italian Government. Their names are *Aquila*, *Sparviero*, *Nibbio*, *Falko*, and *Avoltoio*. The following particulars of these vessels have been supplied to us: They are 46.5 meters long (151 ft. 8 in.) and 5.2 meters wide (17 ft.) The draft of water is 2.3 meters (7 ft. 6 in.). The hull is divided into 12 water-tight compartments, there being also longitudinal bulkheads. The vessel will continue afloat if all compartments forward of the boiler are filled with water.



FIRST-CLASS TORPEDO BOAT FOR THE ITALIAN NAVY.

Each vessel is fitted with two locomotive type marine boilers with 1,700 sq. ft. of heating surface, and two sets of triple-compound engines. The latter are placed amidships, while the boilers are placed fore and aft, the propeller shafts passing at the side of the after boiler. The cylinders are 17 in., 26 in., and 37 in. in diameter by 17 in. stroke. The total horse-power developed by the engines is set down at about 2,200 indicated; the boiler pressure is 13 atmospheres, and the air pressure in stoke-hold 30 mm. to 40 mm. (1.18 in. to 1.58 in.). The propellers are three-bladed and of 1.8 meters diameter (5 ft. 11 in.). There are auxiliary engines for electric light, steam steering gear, and an air compressor for torpedo discharge for the bow tube, the tubes on deck ejecting their torpedoes by powder. The boiler and engines are entirely enclosed by the coal bunkers, as shown in our illustrations. There is also an electric signal apparatus. The three torpedo tubes are arranged as shown in the engraving, the complement of torpedoes carried being six. There are two Hotchkiss guns. The coal bunkers have a capacity of about 40 tons, with which these vessels can steam for a distance of 5,000 miles at 10 knots speed. All compartments have large bilge ejectors, which together can discharge 800 tons of water per hour. The displacement of the boats, fully equipped and with full bunkers, is 160 tons. The displacement during trial was 145 tons. The details of the trial displacement were as follows: Boilers and engines, with water, etc., 61; coal, 14; torpedoes, munitions, etc., with 24 men, 7.5; vessel, guns, electric engines, signals, masts and rigging, 62.5; total, 145 tons.

The trials of these boats were made in the Baltic, near Pillau, the course being defined by fixed landmarks placed 19 miles apart. Each boat ran at full power for three hours, and the following results are given:

Aquila, tried July 28, 1888. Strength of wind, 4, with strong running sea; mean speed, 26.2 knots.

Sparviero, tried August 6, 1888. Wind, 3; mean speed, 26.6 knots.

Nibbio, tried August 22, 1888. Wind, 2; mean speed, 26.8 knots.

The horse-power is stated to have been about 2,000 indicated, and the engines worked without any hitch at an average speed of from 320 to 325 revolutions per minute. The boats are said to have turned in a circle of 300 meters by using the twin screws.

In the illustrations, fig. 1 is a general view of one of these vessels. Figs. 2, 3, and 4 are respectively a longitudinal section, a plan with deck removed and a deck plan of the same vessel. In fig. 5 we give indicator diagrams taken from the engines of the *Aquila*, which well repay careful examination. The boiler pressure was 13 atmospheres and the vacuum 13.37 lbs. The revolutions were 325 per minute. These diagrams must have been taken at full speed, as they work out very nearly the 2,200 indicated H.P. given as the power required for full speed. Figs. 6, 7, and 8 show the wave line of the *Aquila* and sister vessels when running at 14, 18, and 26.5 knots speed respectively. In the diagram, fig. 9, are given curves showing coal consumption, indicated horse-power, slip of screw, and revolutions at speeds varying from 10 knots to 28 knots per hour.

The following details are given of five other boats built for the Italian Navy: 39 meters long (128 ft.) and 4.8 meters wide (15 ft. 9 in.); draft, 2.2 meters (7 ft. 2 in.); displacement, fully equipped, 85 tons; engines of triple-compound type, developing 1,200 indicated H.P. The contract speed was 21.5 knots during a three hours' run at sea. The actual speed obtained was 22.5 knots. We presume this was the best out of these five boats.

The ten boats made the passage from Elbing to Spezia, and encountered rough weather on the way. They all, however, arrived safely, making the run in short times. At the present time there are building at Elbing, besides some 30 other vessels, one twin-screw boat for the Russian Government, with a guaranteed speed of 26½ knots, and five of the same type for other orders.

THE ABT RACK-RAILROAD.

In previous numbers of the JOURNAL—for November, 1888, page 442, and for January, 1889, page 12—reference has been made to the Abt rack-rail system for mountain railroads, which experience has so far shown to be the best yet tried for working steep inclines by locomotive power. The following account of the latest locomotive for a rack-railroad, with some account of the experience gained on such a road, is condensed from a paper read before the Technical Railroad Union in Berlin recently by Herr Schneider, Director of the Harz Mountain Railroad, one of the first lines built on Herr Abt's plans :

It will be remembered that one of the distinguishing features of the Abt system is the arrangement of the rack-rail. This consists of three plates or bars of steel laid on the ties, in the center between the ordinary rails, the teeth being cut on the upper edges of these plates, which are held place by chairs of appropriate form, spiked to the ties, and in are set at a distance apart from each other about equal to their thickness. In setting the teeth are stepped by each other one-third of their pitch, and the pinions which work in them are made to correspond. Owing to the thinness of the rack-plates, they are easily bent to correspond to any curve in the track.

At points where the rack-rail begins or ends—that is, where the transition is made from the rack-railroad to the ordinary adhesion-railroad—a short section of the rack is connected by a hinge-joint, allowing it to move vertically. This section is supported by springs, allowing the pinions to enter on the rack, and the teeth to enter into gear without shock.

The rack-bars used on the Harz Mountain Railroad are 0.78 in. thick, 4.33 in. deep, and 8.65 ft. long ; they are of Bessemer steel. In laying they are always placed so as to break joints.

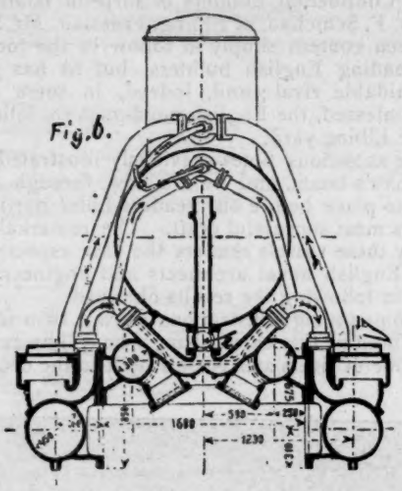
As a part of the line only is on the rack-rail system, the locomotives are adapted to work on this system or on an ordinary track as desired. The latest engine built for the road, which includes the improvements shown by experience to be desirable, is shown in the accompanying illustrations, fig. 1 being a longitudinal section ; fig. 2 a half-plan, showing the running gear ; fig. 3 a half-section through the fire-box ; fig. 4 a half-section through the smoke-box ; fig. 5 a cross-section, showing the rack-rail and pinions. The dimensions on these cuts are in meters.

This locomotive may, in fact, be said to consist of two separate engines served by one boiler and carried on one set of frames.

Considered as an ordinary or adhesion locomotive, it is a tank engine having outside cylinders, three pair of driving-wheels, coupled, all in front of the fire-box, and a Bissell truck back of the fire-box. The total driving-wheel base is 10 ft., and the distance from center of rear drivers to center of truck is 7 ft. 10.5 in. The driving-wheels are 49.2 in. and the truck wheels 29.5 in. in diameter. The cylinders are 17.7 in. in diameter and 23.6 in. stroke. The frame is of the plate type generally used in Europe. The pedestals carrying the driving-boxes are secured to the frame by angle-irons ; between the boxes and the pedestals of the rear and middle axles only the usual play is allowed, but the boxes of the forward axle have additional play, in order to allow the wheels to accommodate themselves to the sharp curves, and to prevent too much flange-wear. The center of the radius-bar of the truck is 4 ft. 7.1 in. from the center of the axle.

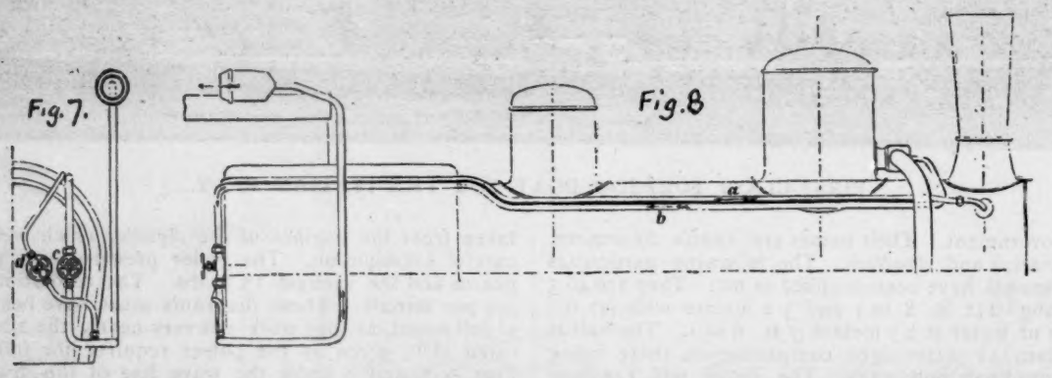
The boiler barrel is 54.33 in. in diameter and 13 ft. 3.4 in. long. The fire-box is 5 ft. 6.9 in. long and 3 ft. 7.3 in. wide. The heating surface of the fire-box is 89.4 sq. ft. ; tubes, 1,374.4 sq. ft. ; a total of 1,463.8 sq. ft. The grate area is 19.4 sq. ft. The usual working pressure is 150 lbs. The center of the boiler is 7 ft. 10 in. above the level of the rails.

The only peculiarity in the boiler is the double throttle placed in the dome. One of these valves admits steam to



the steam-chests of the ordinary cylinders, the steam-pipes being carried down outside the boiler, as shown in figs. 1 and 4 ; the other admits steam to the rack-rail cylinders, the steam-pipes passing through the smoke-box.

The total weight of the engine in full working order is 55 tons, of which 43 tons are carried on the driving-wheels and 12 tons on the truck. The tanks will hold 1,750 gals. of water, and the coal bin about 4,400 lbs. of coal.



The second or rack-rail engine consists of the two pinions which gear in the rack-rail, and the two inside cylinders placed in the smoke-box. These cylinders are set at a considerable inclination, and have the steam-chests underneath, as shown in fig. 4 ; they are 11.8 in. in diameter and 23.6 in. stroke. The pinions are 22.56 in. in diameter to the pitch line and are carried each on an axle or shaft of its own. The teeth on these pinions are 4.72 in. pitch, and they are made in three sections, to match the triple rack.

The cylinders of the rack-rail engine are necessarily set high, in order that the connecting rods may clear the main axles. These connecting rods act upon rocker arms keyed on an independent axle carried in bearings upon the main frame, as shown in figs. 1 and 5. From the shorter arms of these rockers a connecting rod runs to crank-pins on the outer ends of the rear pinion shaft. The two pinion shafts are coupled by parallel rods, as shown in fig. 2.

The pinion shafts or axles are carried by two plate frames, which are carried by the main driving axles, as shown in fig. 2. By this arrangement the pinions are kept always at the same height, and the relative position of the pinions and the rack-rail is not affected by the motion of the locomotive on its springs.

The link-motion for the valves of the rack-rail cylinders is worked from eccentrics on the main or rear pinion shaft. The valve-motion for the main cylinders is outside the driving-wheels.

The rack-rail cylinders are cast with flanges on the outer side, through which they are bolted both to the frames and to the main cylinders; the latter being cast with long flanges inside for this purpose. This arrangement, which is shown in fig. 4, makes a very solid job.

Originally the exhaust pipes from both sets of cylinders were led into a single exhaust nozzle, which was provided at the top with an arrangement of the Polonceau type for varying the area of the opening. It was found, however, that when both engines were working, and were not running evenly together, the exhaust steam from the adhesion-cylinders would be drawn into the rack-rail cylinders, interfering with their proper working; moreover, the blast was irregular and the fire would get into bad condition. To remedy this a new exhaust nozzle was put on, with separate passages for each set of cylinders. This at once removed the trouble, and the steaming qualities of the boiler were so much improved that 15 tons could be added to the train without diminishing the speed.

The engine is provided with the ordinary screw-brakes, the brake-shoes acting on the driving-wheels. There are also brakes working on brake-wheels or disks attached to the pinions; these can be applied by a brake-wheel or lever placed on the fireman's side of the cab, as shown in fig. 1. Besides these two brakes there is also an arrangement by which air can be admitted to the cylinders and, by its compression in them, used as an additional brake power. This is shown in figs. 6, 7, and 8. In figs. 7 and 8 *a* is the air-pipe and *d* the air-escape valve from the rack-rail cylinders; *b* the air-pipe and *c* the air-escape valve from the large cylinders. These are so arranged that the engineman can use the brake power of either pair of cyl-

LOCOMOTIVE FOR THE HARZ MOUNTAIN RAILROAD, ABT RACK-RAIL SYSTEM.

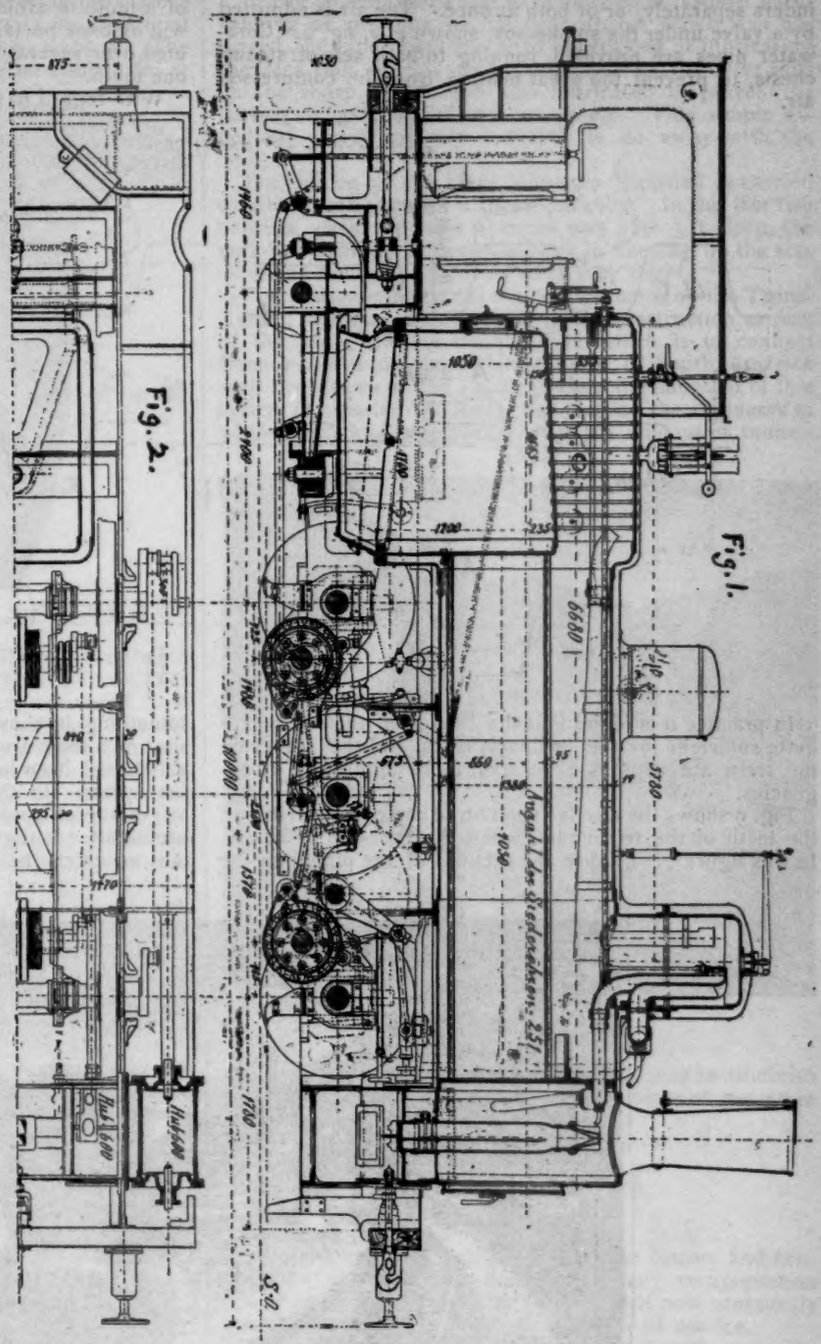


Fig. 1.

Fig. 2.

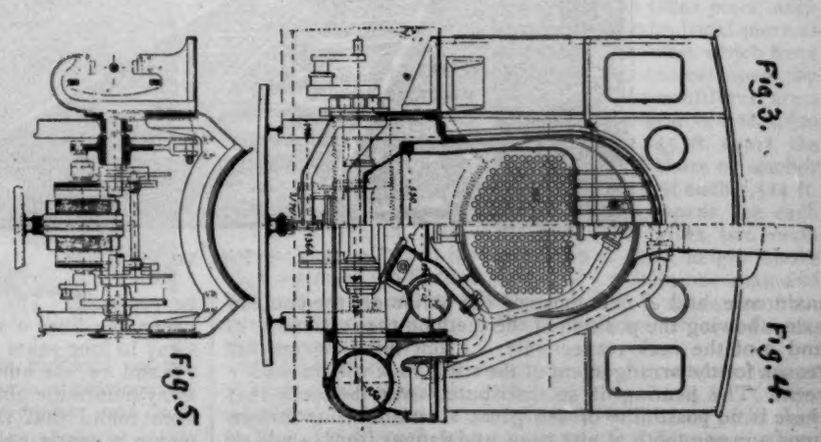


Fig. 3.

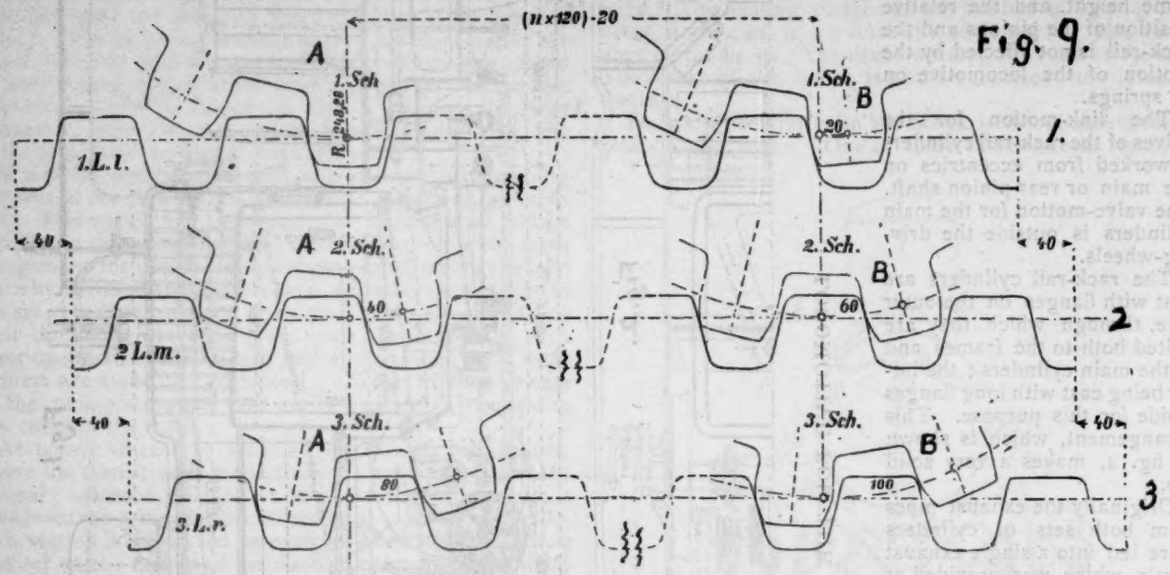
Fig. 4.

Fig. 5.

inders separately, or of both at once. The air is admitted by a valve under the smoke-box, shown at *e*, fig. 6. Cold-water pipes are provided, running to both sets of steam-chests, to prevent too great heating from the compressed air.

of a tooth is avoided. Even should one break, the strain will at once be taken up by the others, and being distributed over several, there will be no sudden shock to any one tooth.

With regard to the wear of the teeth upon the rack-rail



In practice it is found that the brakes on the engine are quite sufficient for the ordinary stops, and the brakes on the train are kept as a reserve, to be applied in emergencies.

Fig. 9 shows the relative position of the pinion teeth and the teeth of the triple rack when the rack-rail is in use. In this figure *A A A* are the sections of the pinion on the

something is shown by fig. 10, which is a section (full size) of a tooth from a pinion on the locomotive *Brocken*, which had been in use, in regular service on the road for four years. In this figure the outer lines *a a* show the original profile of the tooth; the middle lines *b b* the profile after four years' service; the inner lines *c c* the extent to which the tooth can wear before the pinion must

Fig. 11.

main axle, and *B B B* those of the pinion on the coupled axle, showing the position of the teeth on the sections 1, 2, and 3 of the rack respectively. From this diagram the reason for the arrangement of the triple rack will be readily seen. The bearing is so distributed over the teeth that there is no possibility of too great a strain being thrown upon any one tooth at any time, and danger from breakage

be replaced. The full black portion on either side, between the lines *a a* and *b b*, is the amount of metal worn away in four years; the heavily shaded portions, between *b b* and *c c*, the amount of metal which can still be worn away before the pinion is thrown aside. In practice it has been found that the wear of all the teeth on the same pinion is nearly uniform.

It may here be repeated that the diameter of the pinions to pitch line is 22.56 in.; over all, 24.13 in.; pitch of teeth, 4.72 in.; width of teeth when new, 2.205 in. The wear after four years was about 0.158 in. on either side, at

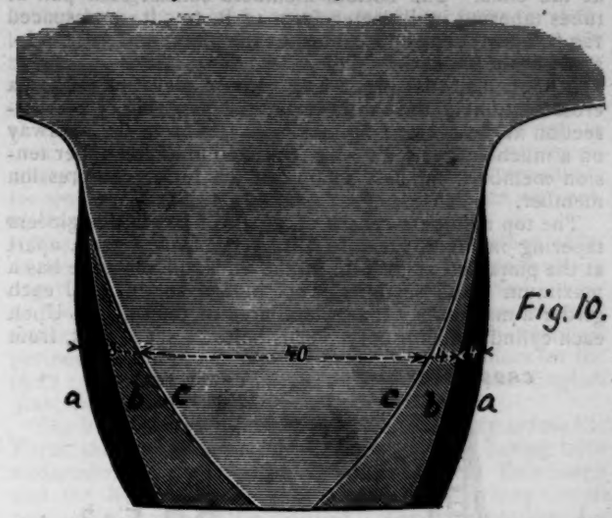


Fig. 10.

the widest point, reducing the width of the tooth to 1.889 in.

In running these locomotives it must be remembered that the engine-driver has, in fact, two separate machines under his charge. In addition to the care demanded from the driver of an ordinary engine, he has, therefore, to watch for the proper times for making the transition from the rack-rail engine to the adhesion engine, and *vice versa*. On the Harz Mountain Railroad, at each point where the rack-rail begins, double signals, designated as *A* and *B*, are provided. These indicate to the engine-driver the points where the throttle should be opened to admit steam to the rack-rail cylinders and where the other throttle should be closed, to shut off steam from the adhesion-cylinders. Of course, in leaving the rack-rail the process is reversed.

An average train on this road consists of a passenger car, a baggage car, an "outlook car," and four to five freight cars. The cars—both passenger and freight—are all four-wheeled cars.

Of the three remaining illustrations fig. 11 shows the beginning of a section of rack-rail on the Harz Mountain Railroad near Rübeland; fig. 12 a bridge on the same road

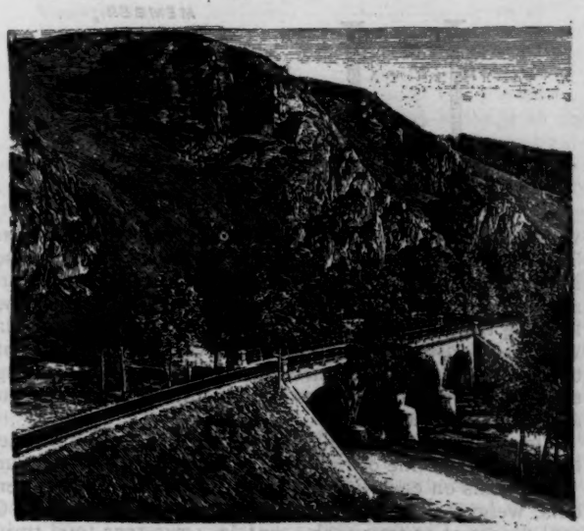


Fig. 12.

near Rothehütte, and fig. 13 a view on the road on the Eichenberge near Blankenberg. For these engravings we are indebted to Gläser's *Annalen für Gewerbe und Bauwesen*.]

It may be mentioned that to remedy an occasional hard-running or grinding of the spur-wheels which was observed, the experiment was tried of greasing or lubricating the rack-rails once a week; the inside of the outer rails on the sharp curves was also lubricated to prevent the cutting or grinding of the car-wheels. This simple expedient proved entirely sufficient to do away with the trouble.

The service on the Harz Mountain Railroad is carried on winter and summer without difficulty. In the last two winters, when the snow at times was over 3 ft. deep, the rack-rail proved the best assistant in keeping up the service, and the delays to traffic were very slight.

The latest application of the Abt system is on the Trans-Andine Railroad, which is now under construction as part of the great transcontinental line which is to connect Buenos Ayres on the Atlantic Coast of South America with Valparaiso on the Pacific. Here the adoption of this system in crossing the Andes has enabled the engineers to adopt much higher grades, reduce the amount of tunnel-

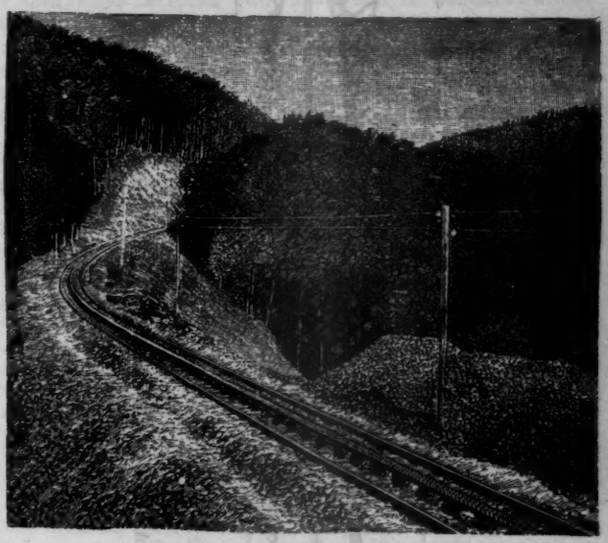


Fig. 13.

ing and other heavy work, and in this way to diminish considerably the cost of a very difficult piece of mountain railroad.

THE FORTH BRIDGE.

So much has been published about the history and construction of the Forth Bridge, that any recapitulation would be superfluous, but as the bridge is now practically completed, a general description may be of service.

The bridge proper is 5,349 ft. 6 in. in length, and consists of two cantilever spans resting upon three piers, each pier being made up of a group of four cylindrical piers of masonry, each carrying one of the iron towers which form the support of the cantilever. In the central span the tubular columns are 260 ft. apart and the cantilever arms project 680 ft. on each side, making the total length 1,620 ft. In the two others the columns are 145 ft. apart, the cantilever arms project 680 ft. and the shore or anchor arms 689 ft. 9 in., making the total length of each 1,514 ft. 6 in. The two suspended or connecting spans are each 350 ft. in length. As constructed this gives two main spans, each of 1,710 ft. clear, with a clear height above high water of 150 ft. for a length of 500 ft. in one span and of 850 ft. in the other. The span above is made up of the two projecting arms, each 680 ft., and the suspended span, 350 ft.; total, 1,710 ft.

The approach on one end consists of one truss span of 173 ft.; three of 168 ft. each, and one of 179 ft. On the other end there are 10 truss spans: One of 173 ft.; then eight of 168 ft. each, and one of 179 ft. The general ar-

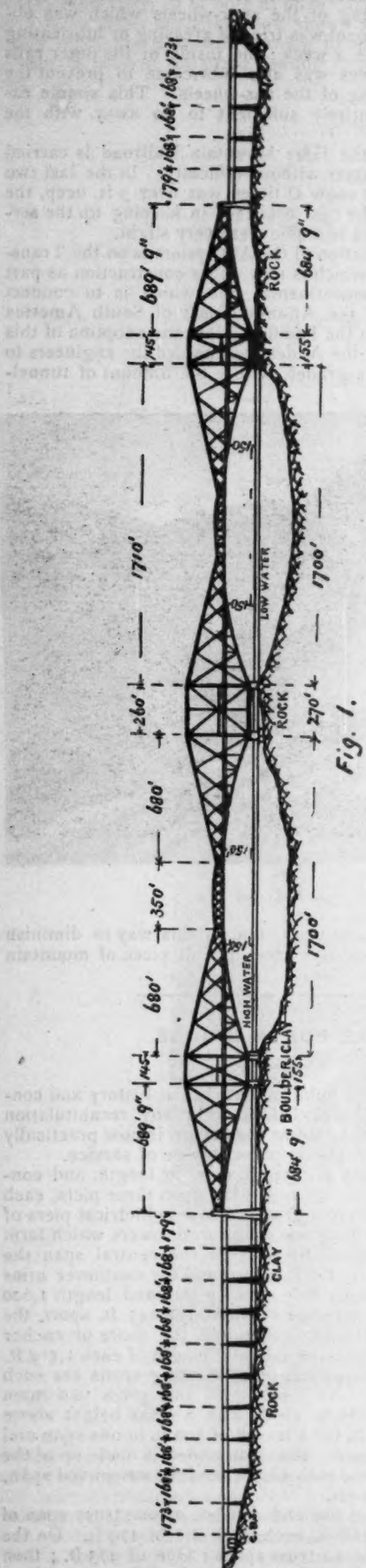


Fig. 1.

SKETCH OF ELEVATION OF THE FORTH BRIDGE.

rangement of the bridge is shown in the accompanying sketch.

The cantilevers are 343 ft. deep over the piers and 40 ft. at the ends. The bottom members consist of a pair of tubes tapering in diameter from 12 ft. to 5 ft., and spaced 120 ft. apart, center to center, at the piers, and 31 ft. 6 in. apart at the ends.

In the illustration fig. 1 is a general elevation; fig. 2 a cross-section of the cantilever at the pier; fig. 3 a cross-section at the center; fig. 4 a cross-section of the roadway on a much larger scale; fig. 5 a section of the upper tension member; fig. 6 a section of the lower compression member.

The top members consist of a pair of box lattice girders tapering in depth from 12 ft. to 5 ft., spaced 33 ft. apart at the piers and 22 ft. 3 in. at the ends. Each tube has a maximum gross sectional area of 830 sq. in., and each girder a maximum net sectional area of 506 sq. in. Upon each cylindrical masonry pier is bolted a skew-back, from

Fig.3.

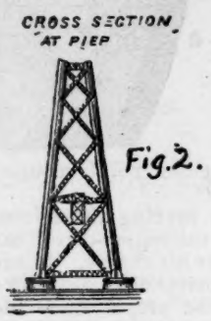
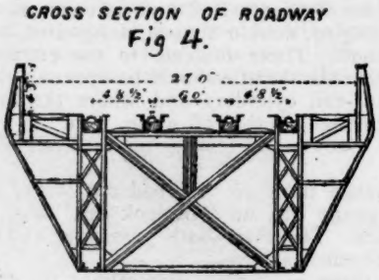


Fig.2.



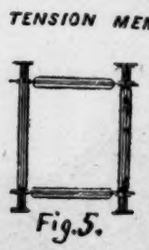


Fig.5.

Fig.6.

which spring vertical and diagonal columns and struts. The former are 12 ft. in diameter and from 368 to 468 sq. in. in sectional area; the latter are flattened tubes. Horizontal wind-bracing of lattice girders connects the tubes forming the bottom members of the cantilevers, and similar vertical wind-bracing connects the vertical and diagonal tubes, so that the whole structure is a network of bracing, capable of resisting strains in any direction and of any attainable severity.

The rolling load provided for is: 1. Trains of unlimited length on each line of rails, weighing one ton per foot run.

2. Trains on each line made up of two engines and tenders, weighing in all 142 tons, at the head of a train of 60 coal-trucks of 15 tons each—that is, 1,042 tons total train-weight.

The wind-pressure provided for is a pressure of 56 lbs. per square foot striking the whole or any part of the bridge, at any angle with the horizon, the total amount on the main span being estimated at no less than 7,900 tons. In practice, only two trains, weighing 800 tons in all, would be

on this length of bridge at one time, so that the wind-pressure—if such a hurricane as would produce a pressure of 56 lbs. to the square foot should come—would be nearly 10 times as great as the train-load.

Under the combined stresses resulting from the test-load in the worst position and the heaviest hurricane, the maximum stress on the steel will not exceed 7½ tons per square inch on any portion of the structure, and on members subject to great variations in intensity and character of stress, the maximum will not exceed 4 tons per square inch. For tubular columns and struts 34 to 37-ton steel, with an elongation of 17 per cent. in 8 in., was specified: for tension members, 30 to 33-ton steel, with 20 per cent. of elongation.

The contract for the bridge was let in December, 1882, to the firm of Tancred, Arrol & Company—a firm specially organized for this contract—the price specified being £1,600,000. The bridge has thus been nearly seven years under construction. Some of the greatest difficulties experienced were in sinking the great 70-ft. cylinders for the piers. The structure is built throughout on the English plan, with riveted joints.

The bridge carries the North British Railway across the Forth, the total expenditure of over $8,000,000 having been undertaken to shorten the distance between Edinburgh and the North of Scotland, by avoiding the long circuit previously made by the railroad. The construction of a bridge was first proposed in 1865, and various plans were submitted before the design now finally carried out was adopted. This design was the work of Sir John Fowler and Mr. Benjamin Baker.

NATIONAL REGULATION OF RAILROAD SAFETY APPLIANCES.

We give below the greater part of the remarks contained in the third annual report of the Interstate Commerce Commission on this subject:

Personally concerned as every man is in the safety of travel the subject of railroad accidents has always had the greatest popular interest. That the facts are quite sufficient to warrant this interest may be seen from the following figures taken from the annual reports of the railroads of the country made to the Commission for the year ending June 30, 1888. There were reported for that year deaths and injuries to persons as follows:

Passengers killed	315
Passengers injured	2,138
Employés killed	2,070
Employés injured	20,148
Other persons killed	2,897
Other persons injured	3,602
Total persons killed	5,282
Total persons injured	25 888

But the reports do not cover the total mileage of the country; only 92.792 per cent. of it. If the accident rate was the same on the roads not reporting, the total number killed was 5,693 and the total injured 27,898. These are the returns made by the railroad companies themselves, and they cannot well be suspected of exaggeration. Neither is there, on the other hand, any reason to suppose that they are not, in most cases, complete and prepared with perfect good faith.

A thought strikingly suggested by these figures is that accidents to passengers take up an undue proportion of the public attention. Not only are casualties to employés several times more numerous, but they are concentrated upon a comparatively small class, each individual of which undergoes considerable hazard. Some estimate of how great this hazard is in the case of one class of employés may be made from the records of the Brotherhood of Railroad Brakemen, an organization that has for one of its objects the insurance of its members against death or total disability. During the year 1888 the average membership of this Brotherhood was 10,052.5. Insurance has been paid upon 114 deaths and 53 total disabilities, the result of injuries received from railroad cars during that year. In the same time there were only 31 deaths and 6 total disabilities from natural causes. These data are taken from the printed assessment notices of the order. Thus one in every 88 of the members of this organization is killed yearly, and one in 60 suffers either death or total disability. It appears also that a brakeman has only 31 chances in 145, or 1 in 4.7, of being allowed to die a natural death.

Exception may, perhaps, be taken to this conclusion on the ground that brakemen are mostly young and vigorous men not likely to die from natural causes, but surely this view of the case is not more satisfactory than the other. No record is kept showing the number of lesser injuries received, but if the ratio of killed to wounded is taken as the same as that which, according to the figures quoted above, holds good in accidents to railroad employés over the country at large, namely, 1 to 9.73, the number of those receiving injuries serious enough to be reported to the Commission would be, exclusive of the killed, 1,109, or 1 in 9 of the members of the order. It would appear from this result that, besides running great danger of death, a brakeman will, on the average, be injured once for every nine years of service. It should be said that this Brotherhood includes quite a number of conductors and others whose occupation is less dangerous than that of brakemen, so that the hazard to brakemen is presumably somewhat greater than here shown. It is probable that no occupation followed in this country by any large class surpasses in danger that of the railroad brakemen.

It having been urged upon the Commission from several quarters, but more particularly by the State Railroad Commissioners at the Convention in March, that there was a necessity for some sort of national action in matters relating to safety on railroads, an investigation of the subject was begun in the spring of the present year. Although information has been obtained principally from miscellaneous sources, two circulars have been issued making inquiry concerning matters of special importance. The first, dated April 1, dealt especially with automatic freight-car couplers, and called not only for facts but for technical opinion. It was addressed to the heads of the car-building departments of all the leading roads. The second, issued May 17, concerned the general subject of Federal regulation of the mechanical features of railroad working, and was intended to call out from those best informed and most interested the fullest discussion of that subject and of the facts bearing upon it. It was addressed to all State Railroad Commissioners, to the Grand Masters of the chief organizations of railroad employés, and to a number of railroad experts and others who were known to have made special study of the matters in question. A number of the replies to this circular were prepared with much care and have great value, being, in fact, thoughtful discussions of the matters suggested by the circular, written from various points of view by men of ability and special knowledge.

The question of the prevention of loss of life and limb on railroads has received study of late years from various quarters. It has been carefully investigated by the various State commissions whose reports have served as a guide to legislatures, to public sentiment, and often to the railroads themselves. In no direction has inventive and executive mechanical genius been more active or, on the whole, more successful. Some of the American inventors are not unworthy to be classed with Stephenson himself for what they have done to aid and perfect railroad transportation. But perhaps the most important work of all, as far as mechanical appliances are concerned, has been done by the Master Car-Builders' Association, an organization little known to the general public, developed by the railroad corporations themselves to meet certain requirements of modern railroading. This Association meets annually, and, as regards one of its most important purposes, may be not inappropriately described as a federal assembly of car-shops, in which each railroad corporation has a voice, proportioned to the number of cars it owns, in determining upon those standards of uniform construction which extensive interchange of cars makes necessary. The conclusions of this body are recommendatory and not binding upon its members, its careful methods of procedure, likely to assure the best results, and the economies dependent upon uniform construction being relied upon to support its recommendations. Any improvement in safety appliances, then, which depends for its success upon uni-

form action by railroads all over the country, and the most important do so depend, must first secure the approval of the Master Car-Builders' Association.

The importance of this Association will further appear in the course of a brief sketch of some of the problems relating to public safety which apparently call for solution through national legislation.

(This is followed by a condensed account of the action so far taken by the Association on Automatic Couplers, on Freight Train Brakes, and on Car Heaters, and of the legislation on the same subjects in different States. Opinions of several of the State commissions are also given.)

PROBLEM OF FEDERAL REGULATION.

If it is assumed that the condition of things thus briefly outlined calls for some Federal action in the interest of safety, particularly of the safety of workmen in railroad employ, it remains to consider what that action should be.

Two distinct ways of proceeding are naturally suggested. Congress may, should it see fit, pass definite statutes requiring that certain appliances be brought into use upon all the railroads of the country within a certain time; or, having in view the difficulty and importance of the question, it may prefer to make some provision for its further investigation, trusting that the mere fact that such an investigation is in progress will not be without immediate results.

This Commission is not prepared to recommend a national law prescribing appliances. It does not assume to say that such legislation will never be advisable, but it is not prepared to say that it is advisable at present. The difficulties of formulating a law from which good results could be expected are certainly very great, if not insurmountable, and, although pains have been taken to secure the views of all interested, no legislation of this sort has been suggested that seems plainly to be wise and safe. A statute requiring that all freight cars be fitted with automatic couplers by a certain date—a requirement against which it is probable that less could be urged than against any others suggested—has already been shown to be open to serious objections. It is impossible to say what the results of such a law would be, but there is no certainty that they would be good. If it did not bring about uniformity—and there is no assurance that it would—it would be most injurious to all interests involved, including those of public safety.

While it is no doubt highly desirable that results be reached as soon as possible, it is still more desirable that no mistakes be made. Nothing could be more unfortunate than a repetition, on an enormous scale, of the unsatisfactory results of State legislation. If the State statutes of a few years ago regarding couplers had been national statutes, it seems plain that the question would be in less hopeful condition than it is at present. The effect of that legislation was to hasten the adoption of a variety of automatic couplers, most of which must, of course, be set aside if uniformity is to be attained. In fact, the strongest opposition to the Master Car-Builders' type of coupler—the one that, so far as can be seen, has most chance of uniform adoption—is found in New England, where, as a result of State legislation, automatic couplers not of that type have secured a strong hold. A reasonable prudence and regard for the lessons of previous experience require that action involving the compulsory use of particular appliances should be undertaken only with the greatest caution and upon more thorough investigation than has as yet been practicable. It has been suggested that for the present, at least, the interests of safety would be better served by providing for a board of specialists, so constituted as to command respect from both the railroads and the public, whose business it would be to make investigations and recommendations relating to railroad casualties.

To determine in detail precisely how such a board or bureau should be organized, just how much it should be expected to accomplish, and what powers should be given it, is a matter of much delicacy, in the study of which careful attention should be given to bodies of a similar sort now in existence.

Although we have had in this country no national inspection of railways, we have had for nearly 50 years something closely analogous to it in the steam-boat inspection service. And to find a nation which undertakes the inspection of railways with a view to the protection of human life we need go no farther than England, a country where the relations between railways and the Government are in many respects similar to what we have at home. Such inspection is also undertaken in the countries of the Continent of Europe, but as the conditions in those countries are much less like our own than those in England, their methods are not so instructive. These two examples of effort on the part of Government to increase the security of human life, the steam-boat inspection service of the United States and the English system of railway inspection, may profitably be regarded as representative of two distinct principles, both of which may be usefully studied in dealing with the subject now under consideration. In the former we have an example of an inspecting agency which not only investigates safety appliances and makes recommendations and reports, but also has considerable powers of actual interference and control. In the English statute under which inspectors are appointed it is expressly provided that "no person so appointed shall exercise any powers of interference in the affairs of any company." Both systems are successful, but it is clear that this success must be achieved in somewhat different manners. It is clear also that the inspecting agency, which has the more power, will require the more elaborate organization and incur the greater responsibilities. The system of steam-boat inspection under our own laws is assumed to be familiar; a brief statement of the system of railway inspection in England is here given.

Although the English system of inspection of railroads by officers acting under the direction of the Board of Trade dates back to 1840, the statute determining the powers and duties of the present inspectors was passed, like our act to regulate steam-vessels, in 1871. That statute, after authorizing the appointment of inspectors, "provided that no person so appointed shall exercise any powers of interference in the affairs of any company," gives each inspector power to inspect any railroad, and all its stations, works, buildings, rolling stock, etc.; to require the attendance before him of any person in the management or employ of a company; to require such person to answer his inquiries, and to enforce the production of any papers he considers important for his purpose. Provision is also made for a more formal investigation in very serious cases to be conducted by a court, consisting of an inspector and persons designated by the Board of Trade to assist him. Such a court has no power beyond what is necessary for investigation. Its function ends when it submits a report of its findings to the Board of Trade.

Under this act the Board of Trade appoints as inspectors three officers detailed from the Royal Engineers.

Their position is practically a permanent one, and they are, of course, men whose character and abilities command respect from all quarters. Whenever an accident occurs in the United Kingdom of which the Board of Trade desire to make investigation (there need not necessarily have been any loss of life) one of these officers is selected to make it. He proceeds to the scene of the accident, conducts his investigation, and makes his report. As soon as this is printed a copy is sent to the management of the company on whose line the accident occurred. A blue book containing these special reports, together with complete accident statistics, is published quarterly. The number of reports for each quarter, of course, varies greatly, but the average is about 25. They enter into minute detail and yet are clear and vigorous. A short account of the accident and the damage done in it comes first; then follows a careful description of the surroundings; then the evidence in a concise form; and finally the concluding portion, in which the accident is discussed, responsibility fixed, and recommendations made.

The only power in the nature of actual interference which inspecting officers exercise is in the case of a new line. Such a line cannot be opened till the Board of Trade gives its sanction, and the inspecting officers can and do require that everything that they think necessary for safety be provided before they recommend that this sanction be given. But when sanction is once given, the Board has

no further power. After the line is open the company may even remove works which it has erected to obtain the Board's sanction ; and there is no remedy.

Besides the quarterly publication of returns of accidents already mentioned, two other documents, relating to safety appliances, are regularly issued by the Board of Trade. One is issued half-yearly, and relates to continuous brakes on passenger trains. It is made up chiefly of returns which the companies are by act of Parliament required to make, showing in the most complete manner the number and proportion of passenger cars fitted with continuous brakes, the kind of brakes used, every case of failure of continuous brakes to act, giving cause of failure in detail, and in general the progress in the use of continuous brakes from year to year. The second document is published yearly and contains similar returns relative to the interlocking of switch and signal levers and the block system. The purpose of these publications seems to be to assure complete publicity, to keep the people and the railroads themselves alive to what the latter are or are not doing, and at the same time to furnish data from which the efficiency of various appliances may be studied. In addition to these regular publications the Board from time to time issues circulars pertaining to matters in which especial pressure seems to be necessary.

Although the success of this unpretentious system of regulation has been very decided, there has frequently, at times when accidents appeared especially numerous, been considerable agitation to have the supervisory authority of the Board of Trade extended. After investigation, however, the proposition to give the Board powers of direct control has invariably been rejected, and none have opposed it more strongly than the Board itself and its inspecting officers. During the past 30 years the prevention of accidents has several times been the subject of parliamentary inquiries, the most thorough of which was made by a royal commission appointed in 1874. Their report, presented three years later, is accompanied by a quarto volume of evidence, containing 1,150 pages.

Regarding an extension of the powers of the Board of Trade, they speak as follows : . . . " Upon full consideration we are not prepared to recommend any legislation authorizing such an interference with railways as would impair in any way the responsibility of the companies for injury or loss of life caused by accident on their lines. To impose on any public department the duty and to intrust it with the necessary powers to exercise a general control over the practical administration of railways would not, in our opinion, be either prudent or desirable. A Government authority placed in such a position would be exposed to the danger either of appearing indirectly to guarantee works, appliances, and arrangements which might practically prove faulty or insufficient, or else of interfering with railway management to an extent which would soon alienate from it public sympathy and confidence, and thus destroy its moral influence, and with it its capacity for usefulness."

This reasoning seems to be amply supported by the evidence, and, together with the objections noticed in considering the steam-boat inspection service, is believed to be conclusive against the institution of an administrative agency with power to enforce upon railroads the use of particular appliances.

In the consideration of the general subject of railroad inspection and supervision it should not be overlooked that there are in many of the States, if not all, statutory provisions of more or less vigor for the inspection of railroads in the respective States by State officials. The reports of some of the State railroad commissions show that their inspection of the railroad as a structure is very thorough. Some of the reports are also very full and complete as to accidents, showing their cause, nature, and extent, and in establishing the individual responsibility therefor when negligence or want of care was the cause. Twenty-six States have already provided for State commissions, with powers and duties varying somewhat in degree, but of the same general character. The tendency is in the direction of increased power and duties in these boards. Judging from their rapid growth in the past both in numbers and scope, probably every State will soon have a commission upon which will be imposed, among other things, the duty of thorough annual inspection of the roads in each State, respectively, and of investigation of all matters pertaining to accidents and injuries in railroad operations. The necessity for Federal inspection and regulation will exist, as already shown, more especially where uniformity is required in safety appliances in the train equipment.

With these general statements the whole subject is submitted to the wisdom of Congress. It will be perfectly obvious, on what is stated, that if any system of Federal inspection or supervision in respect to railroad appliances is provided for, it must be impossible for the members of this Commission in person to perform the duties of such inspection and supervision.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.*

CHEMISTRY APPLIED TO RAILROADS.
III. LARD OIL.

By C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad.

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(*Continued from page* 35.)

Not the least among the changes produced by the development of the petroleum industry, during the last 25 or 30 years, is the diminution in the use by railroads, of what may be called in general, fatty oils. Thirty years ago, both sperm and whale oils were largely used both for burning and lubrication ; candles made from tallow were also largely used as a source of light. *Lard oil* in its various grades was also used both for lubrication and burning, but the constant diminution in the prices of the petroleum products, together with the constant approximation in usefulness of these same products, produced by improved methods of refining, have almost completely wiped out the use of both sperm oil and whale oil for burning and lubrication, and have, to an enormous extent, diminished the use of lard, neat's-foot, mustard-seed, and other animal and vegetable oils of the same nature, for these purposes. Great as the inroads of petroleum products have been, however, they have not yet succeeded in completely doing away with the use of fatty oils for railroad purposes. For certain uses both in burning and lubrication, a percentage of some fatty oil is still apparently a requisite. No petroleum product has yet been devised which meets all the requirements for an oil to be burned in hand-lanterns, and no petroleum product, so far as we are aware, has yet come forward, which fills all the requirements of a lubricant with perfect satisfaction. Railroads are therefore still continuing to use, although in constantly diminishing quantity, some of the fatty oils both for burning and lubrication. In this country lard oil is used most largely for these purposes ; mustard-seed oil and colza oil are also used as constituents of burning oils, and neat's-foot and tallow oils, to a limited extent, as constituents of lubricating oils. In the North of Europe, colza oil is almost entirely the fatty oil constituent of both lubri-

* The above is one of a series of articles by Dr. C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist of the Pennsylvania Railroad, who are in charge of the testing laboratory at Altoona. They will give summaries of original researches and of work done in testing materials in the laboratory referred to, and very complete specifications of the different kinds of material which are used on the road and which must be bought by the Company. These specifications have been prepared as the result of careful investigations, and will be given in full, with the reasons which have led to their adoption.

The articles will contain information which cannot be found elsewhere. No. I., in the Journal for December, is on the Work of the Chemist on a Railroad ; No. II., in the January number, is on Tallow, describing its impurities and adulterations, and their injurious effects on the machinery to which it is applied. These chapters will be followed by others on different kinds of railroad supplies. Managers, superintendents, purchasing agents and others will find these Contributions to Practical Railroad Information of special value in indicating the true character of the materials they must use and buy.

cating and burning oils, while in Spain and Italy, olive oil is largely used in the same way.

The uses of railroad companies are principally confined to two grades of lard oil, the one known in the market as extra lard oil, or prime lard oil; the second, known under various names as extra No. 1, or No. 1. The first, which is the better grade, is used largely for burning; the second, or poorer and cheaper grade, is used principally for lubrication. Neither of them, so far as we know at present, however, are used unmixed with other oils, for either of these purposes. The uses of these oils in detail will be given in a subsequent article, the present article being confined more especially to the sources, method of manufacture, adulterants, and tests of these oils.

Lard oil, as the name indicates, is made from lard, lard being, as is well known, the fat of the hog. This fat is obtained from the fat tissues in much the same way that tallow is obtained from the fat tissues of the beef, namely, by heat, which causes the enclosing tissues to shrivel and release the fat, the last portions of the fat being removed from the "cracklings" by pressure the same as with tallow. If the hogs are healthy and are freshly slaughtered, the resulting product is known in the market as prime lard, and the material is sufficiently good to be used for culinary purposes. If the animals are not healthy, or if, as frequently happens, the animals during transportation on cars from the feeding place, to the slaughtering establishments, die by becoming smothered, or by being injured in any other way, not only the specially characteristic fat tissues, the same as with healthy freshly-slaughtered hogs, but also all the fat tissues of the animal, are "rendered"—that is, all the fat that is in the animal is taken out as lard, since the animal is worthless for food. Strictly speaking, the fat obtained from animals of this nature is not called lard, its proper name in the market being "grease;" it is also sometimes called "dead hog stock." There are many varieties of grease, some of them so white and clean that no one but an expert would distinguish them from the prime lard. The grading goes down in the scale to greases which are very offensive in odor, and many of them very dark in color, depending on the length of time that the animal has been dead before the fat is rendered.

Extra or prime lard oil should always be made from prime lard—that is, the very best quality of lard that can be obtained. It is to be feared that many times, more or less, No. 1 white grease is used even in making the better grade of lard oil. The extra No. 1, or No. 1 lard oil is made from various mixtures of different grades of grease, and some of the poorer greases are used also in making a grade of oil known as No. 2 lard oil. Very little of this oil, as we understand the matter, is used by railroad companies. As will be readily understood, the prime lard is the most expensive in the market, the No. 1 white grease next, and so on through the different gradings, each lower grade being less expensive. The natural tendency of the manufacturers would be to use as much of the less expensive material as possible in making the better grades of oil.

Speaking chemically, lard is principally a mixture of stearin and olein, which chemical bodies were described in the last article of this series, on Tallow. Stearin is a solid at ordinary temperatures, its melting-point being above 120° Fahrenheit, while olein is a liquid at ordinary temperatures, pure olein remaining liquid, even at a temperature below 50° Fahrenheit. The proportions of stearin and olein in lard are not far from 60 per cent. olein and 40 per cent. stearin. These percentages vary somewhat with the food of the animal, and also, apparently, the chemical composition of the fat of the hog is influenced by the food of the animal.

A very interesting illustration of this peculiarity occurred in our experience a few years ago. Fifty tierces of lard were purchased to be used in making lard oil. On examination this lard had a very low melting-point, and treated chemically did not behave as pure lard made from corn-fed hogs does. It was thought, although not definitely proven, that the lard had been mixed with cotton-seed oil as an adulterant. The information going to the parties, they were somewhat indignant, and refused to receive the lard back, saying that it was perfectly pure hog fat. As the result of further correspondence, they came to Altoona and talked the matter over, and explained that the lard in question was obtained from what are known as mast-fed hogs—that is, hogs that run at large quite a portion of the year in the woods, eating in the autumn large quantities of nuts and other food of this nature, which they could pick up. The shipment in question came from Kentucky. It is doubtless well known that it is customary to harden up the fat of the animal in most places with corn before slaughtering. The parties who furnished the lard in dispute claimed that it was well known in the trade, that lard from mast-fed hogs and also from distillery-fed hogs, had a much lower melting-point and was more oily than that from corn-fed hogs. On looking up the literature of the case, very little was found, and in view of the doubt, and the well-known and unquestioned integrity of the parties furnishing the lard, the shipment was accepted.

The statements in the books, so far as definite statements were made, were practically to the effect that very little was known on the subject of whether the nature of the food influenced the fat secretion, but the general belief among physiological chemists was that it did not. Subsequent correspondence with the professors of physiological chemistry in several of the colleges of the country developed little additional. The question was so interesting, however, that arrangements were made with the parties who furnished this shipment of lard to send to us at Altoona some of the fat taken from a mast-fed hog and for comparison some taken from a corn-fed hog. This was subsequently done and the lard from these two kinds of fat was rendered in the laboratory. On examining the product the same characteristics that had been previously found manifested themselves, namely, the lard from the corn-fed hog corresponded entirely in melting-point and chemical behavior to the usual tests. The fat from the mast-fed hog was, as in the case of the shipment above described, much lower in melting-point, and did not behave under the same tests in the same manner as the lard from the corn-fed hog. So far as this single experiment goes, therefore, the indications seem to be that the food does influence to quite an extent the fat secretion. Samples of these two lards were subsequently sent to one of the technical schools, with the hope that further study would be put on the subject, but no definite conclusions were ever reached. It seems probable that much light might be thrown on the nature of the fat secretion by following out the line here indicated.

It is not difficult to understand that lard oil is simply the oily part of the lard, the olein, the 60 per cent., as above described. In making lard oil, therefore, the problem is, how to separate the olein from the stearin. For this purpose advantage is taken of the different melting-points of the two substances. In the best practice the lard is placed in cellars, usually underneath the ice-house, where the temperature is maintained at about 50° Fahrenheit. As soon as it has become cooled down to this temperature the lard is taken out of the tierces, and put in strong cloths, in packages 12 or 15 in. square, containing about 20 or 25 lbs. in each cloth. These packages of lard in the cloths, are then placed one above another, with a board between, a pile 8 ft. or 10 ft. high being made. A board is placed over the top package and then the whole pile is subjected to pressure. The oily part of the lard, the olein, being liquid at the temperature maintained, is gradually squeezed out by the pressure, runs down over the boards into a conduit at the bottom, and is then conveyed away to storage tanks. The stearin being solid at this temperature, remains behind in the cloths. Gradually, as the oil runs out, the pile settles, and the pressure is maintained either automatically or by screws. Of course this separation being a mechanical one, it is not believed that all the stearin is left behind, nor that all of that which runs out is olein, but the separation is sufficiently good for practical and commercial purposes. The efficiency of the separation is very largely a function of the temperature. If the temperature of the room where the pressing is done is 70° Fahrenheit, larger portions of the stearin go into the oil. The older practice recognizes summer and winter oil, the summer oil being made in the summer, and the winter oil in the winter, as the names indicate. This was before the artificial means of keeping the temperature of the room down

to about 50° Fahrenheit had been made use of, and the oil-makers had to press the oil at whatever temperature the location of the presses and the season of the year gave them. As stated above, however, the best practice now cools the rooms where the pressing is done to a uniform temperature of about 50° Fahrenheit, and it is possible to obtain throughout the year what is known in the market as "winter-strained oil." So far as our observation goes no difficulties arise in the summer season in using summer-strained oil, but an attempt to use summer oil in the winter season may cause difficulty on account of the summer oil congealing at a considerably higher temperature than the winter oil. The stearin which is left behind in the cloths is known in the market as "prime stearin," provided prime lard is used, and is used legitimately and principally to mix with other prime lard, and thus make family lard, which goes to warmer climates, the object of the mixture of stearin with ordinary lard being to raise the melting-point and cause the lard to keep better in the warmer countries. The extra No. 1, the No. 1, and the No. 2 lard oils are made in exactly the same way as has just been described, the difference being the quality of the material from which the oil is made—No. 1 and possibly No. 2 grease mixed making extra No. 1 lard oil, a little poorer grade making No. 1 lard oil, and a still poorer grade making No. 2 lard oil. The stearin from the manufacture of these lower grades of lard oil is legitimately and principally used for soap-making.

The characteristics of the two grades of lard oil in common use on railroads, by which they may be distinguished from each other, are simple. The prime or extra lard oil is slightly olive-green in color, flows at ordinary temperatures slowly, compared with water, has a moderately viscous oily feeling when rubbed between the finger and the palm of the hand, and has a rather characteristic pleasant, sweet odor. The extra No. 1 lard oil of best grade is a very dark amber, or yellowish red, or reddish yellow, or, more accurately, it is the color produced by mixing small amounts of red with large amounts of light olive-green; the No. 1 lard oil is darker red, and the No. 2 lard oil still darker red. The extra No. 1 lard oil flows a little more readily than the prime or extra lard oil, has not quite so viscous a feeling under the finger, and is characterized by a somewhat offensive odor; the No. 1 lard oil is still more offensive, and the No. 2 can hardly be used as a lubricant for oiling machinery or shafting on account of the very offensive odor to the workmen.

The principal chemical distinction between the prime and other grades of lard oil is in the amount of free fatty acid which they contain. As in the case of tallow decomposition sets in as soon, apparently, as the animal is dead, and after two or three days have elapsed, between the death of the animal and the rendering of the lard, quite large amounts of free acid have already been formed. The best quality of prime or extra lard oil should not contain over 0.50 per cent. of free acid. It might be called, however, prime or extra lard oil until the amount of free acid reaches 2.00 per cent. The amount of free acid in the extra No. 1, No. 1, and No. 2 lard oils is variable. In the Pennsylvania Railroad specifications, lard oil is recognized as extra No. 1 until the amount reaches 15.00 per cent. We are not aware that any limits of free acid have been agreed upon commercially, by the different boards of trade, as to the distinctions between extra No. 1, No. 1, and No. 2 lard oils. Formerly the grading of this oil was wholly on color, and this grading still prevails to quite an extent, the odor likewise being used as an element in deciding the quality. This use of color and odor as a means of grading, we regard as entirely legitimate. The color, as we understand it, is due to the oxidation of the free oleic acid in the oil, and the odor is due to the state of decomposition of the animal before the fat is rendered, or possibly to the decomposition of the fat after it has been freed from the tissue. The longer the animal has been dead before the fat is rendered, and the greater the exposure of the grease to the light and air before the oil is made, the darker the color of the oil and the worse the odor. Both these characteristics, therefore, indicate a product that has not been as properly cared for, and has, therefore, not cost as much to produce as oil of better color and odor, and consequently could not fairly claim to be regarded as worth as much as a product having less color and less odor. The difference in price between the extra or prime and the extra No. 1, varies from 3 cents to 12 or 15 cents per gall., apparently depending on the relative supply of the materials from which the two oils are made.

The usual adulterants or falsifications of lard oil are (1) admixture of other oils with it, and (2) attempts to sell the inferior grade for the better grade. Lard oil, especially the extra or prime grade, being the most expensive oil used by railroads, the tendency to mix cheaper grades of oil with it is very great. This tendency was much greater 12 or 14 years ago than it is now. At that time lard oil of the best grade was worth $1 to $1.10 per gall., cotton-seed oil was worth 50 to 55 cents per gall., and the petroleum product which could be used to mix with lard oil was worth 20 to 30 cents per gall. In our experience, embracing now something over 14 years, we have found very little attempt to mix petroleum products with lard oils. This may be due to the fact that very early in the history of the Pennsylvania Railroad Laboratory the testing of lard oil was taken up, and the manufacturers soon became conscious that their product was being pretty carefully examined. There is very little doubt, we think, but that petroleum products are mixed in the market with lard oil, but very little of this material has been offered to the Pennsylvania Railroad Company during the past 13 years.

The attempts to sell inferior grades under the name of a better one will be discussed when we come to the question of tests.

The most dangerous and at the same time the most common adulterant of lard oil is cotton-seed oil, and our experience with this material has been quite an interesting one. The difference in price some 12 or 13 years ago, as stated above, produced a very strong tendency to mix the two oils, and under the pressure produced by competition the manufacturers did not seem to be able to resist the tendency. The importance of this tendency to mix cotton-seed oil with lard oils was not limited to the fact that railroad companies were buying cotton-seed oil, which could be obtained in the market at 55 cents per gall. mixed with lard oil, and paying $1 to $1.10 per gall. for the mixture, but the effects on the service were still more disastrous. This point we will try to make clear.

As has already been stated the prime lard oil is used principally as a constituent of burning oil, the mixed oil made by its use being known in railroad language as "signal oil." This oil is used in the hand-lanterns everywhere, and also for rear-end signals on trains, in switch lamps and other places where signals are maintained. Cotton-seed oil, being what is known technically as a "semi-drying oil," that is, an oil that absorbs oxygen and becomes gummy or resinous thereby, does not burn well. Repeated experiments using cotton-seed oil in place of lard oil, in making signal oil, show that when the wick is new, and the lamp first trimmed, it will burn about eight hours before going out, the second time a little over seven hours, and then the time diminishes to about six hours each time before the lamp goes out of itself. The going out of the lamp is caused by the formation of a crust, which begins at the top of the lamp-tube, when the lamp is burning, and creeps up until it finally covers the whole top of the wick, and prevents further flow of the oil. This crust is apparently an oxidized product of the cotton-seed oil—a semi-resin. The same phenomena occurs in less degree when lard oil, which has been mixed with cotton-seed oil, is used in making signal oil. The same resinous crust forms and ultimately extinguishes the light, the only difference being that the lamp will burn longer before going out. In view of the fact that in the darkest weather signals must burn 14 hours without attention, and in view of the fact that not only the safety of trains, but also the operation of the road with success at all, depends on the maintenance of the signals, the importance of the subject can be inferred.

It is, of course, a legitimate query whether a small percentage of cotton-seed oil might not be used in making signal oil, and this question was made the subject of careful experimentation. The results indicated that possibly 10 per cent. of cotton-seed oil might be used, but in view of the tremendous issues which hang on signals, no at-

tempt was ever made to utilize this information. The losses resulting from a single failure of signals might 10 times over counterbalance any saving effected ; indeed, it has almost passed into a proverb among those controlling such matters on the Pennsylvania Railroad, that no railroad can afford to take any risks in regard to the quality of its signal oil.

The extra No. 1 lard oil, when mixed with cotton-seed oil and used for lubrication, always likewise gives very bad results in service. As has already been explained, the cotton-seed oil being a semi-drying oil, the lubricating oil made by its use is in every sense inferior on account of the rapid "gumming."

At the time referred to above, some 12 to 14 years ago, the extra No. 1 grade was worth from 70 to 80 cents per gall., and the No. 1 possibly from 5 to 10 cents less, and the No. 2 about 15 to 20 cents less. The difference in price between these oils and cotton-seed not being as great, therefore, it would be expected that the disposition to adulterate or mix them would not be as great. But cotton-seed oil being a bright, clean oil, free from odor and color, it was soon found by the manufacturers or dealers that a poor grade of No. 1 or even a No. 2 lard oil might be brought up in appearance to the extra No. 1 grade by adding to it enough cotton-seed oil. We have seen samples of so-called extra No. 1 lard oil, which were only one-half lard oil and which by color and odor would fairly be called extra No. 1. A little calculation will readily show that mixing cotton-seed oil worth 55 cents a gall. with No. 2 lard oil, worth also 55 cents, and selling the resulting mixture at 75 cents a gallon, would afford a nice margin over any probable cost of the labor of mixing.

In view of this state of affairs the question of the purity of the lard oil was made a subject of special study within a year after the laboratory was started. At that time cotton-seed oil was so new, and so little chemical work had been done on it, that almost nothing could be obtained from the literature of the subject to help in detecting its admixture with lard oil. Most of the commercial chemists declared themselves incapable of telling whether a sample of lard oil was adulterated with cotton-seed oil or not, and the general feeling among chemists was that, in the present state of knowledge, it was impossible to do so. In view of this state of affairs rather vigorous study was applied to the question, and more, perhaps, by good fortune than skill, a test was devised which enabled the Pennsylvania Railroad Laboratory to say whether or not a sample of lard oil submitted to it was made from the lard of corn-fed hogs. The test did not decide whether the admixture, if any, was cotton-seed oil or some other kind of oil, and although on test, samples where the proportions of the other oils mixed with the lard oil were known, results could be obtained within a fraction of one per cent., no attempts were ever made to reject oil shipments that contained less than 5.00 per cent. of some other oil.

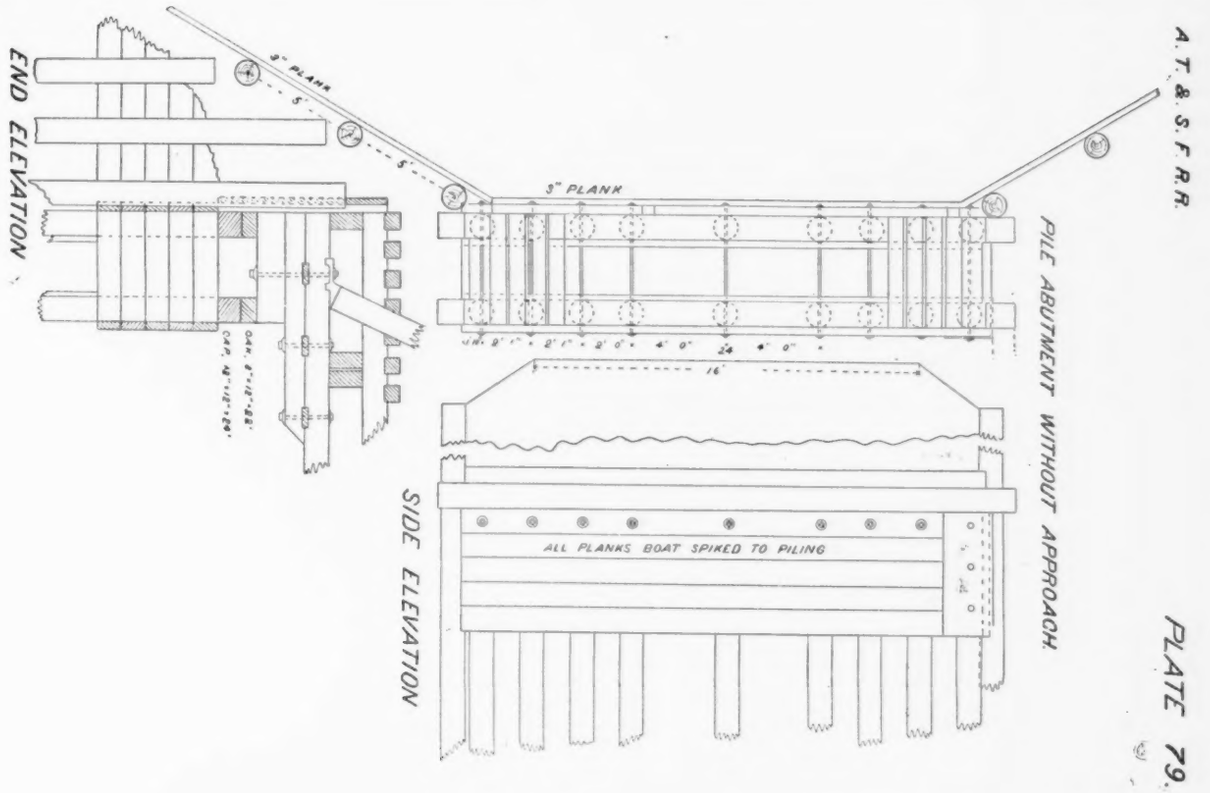
After this test was devised the question arose as to utilizing it, and the Purchasing Department said, with much good sense, that they hardly felt like charging men engaged in business with adulteration or falsification, and accordingly they proposed that the laboratory should be furnished by the manufacturers toward the end of each month with samples of such lard oils as they were willing to furnish for the next month's supplies. These samples being tested, if any of them showed lack of purity, no order would be placed with the parties furnishing this sample. If the sample was all right and an order placed, and the subsequent shipment showed lack of purity, it would be sufficient to the manufacturer to say that the oil was not like the sample. No question of purity or adulteration or falsification was raised, and if the matter went so far as to require a demonstration in the presence of a referee or unbiassed parties, it would certainly be only found necessary to repeat the test of the sample on which the purchase was made and the sample from shipment in the presence of the parties. This method was adopted, and has worked so well, that it has really been in constant force on the Pennsylvania Railroad for some 12 years, and has undoubtedly saved many disputes.

The test and the method of buying having been decided on, the monthly samples on which to make purchases were sent. The first month 13 samples were sent. Some of these samples represented extra or prime lard oil and some extra No. 1 lard oil. Some six or seven different manufacturing firms were represented by the samples. The examination showed that only three of the samples were pure, corn-fed lard oils. The following month 17 samples were sent, and in this case seven samples were pure. In the course of six months it was rare to receive a sample that was not pure lard oil, and in the course of a year or two the contests with the manufacturers over the purity of the different grades of lard oil had pretty nearly all disappeared, and it has been a long time now since either a monthly sample or a shipment of lard oil containing any adulteration or admixture has been offered to the Pennsylvania Railroad.

A single illustration of an actual occurrence during the time of contest for purity of lard oil may be of interest. Soon after the method of buying, above described, had been established, an order was placed with a large firm for 5,000 galls. of prime lard oil, the price being $1.05 per gall. On receiving the shipment a sample was tested and was found to contain 25 per cent. of oil that was not lard oil. This information was sent to the Purchasing Department, who wrote the parties that the oil was not like the sample on which the purchase was made, and if the adulteration was cotton-seed oil there was about 25 per cent. of it ; also requesting the parties to take away the shipment and replace it with pure oil. The parties were very indignant and wrote a somewhat impudent letter, to the effect that the oil was pure lard oil, that their business standing was such that their oil ought not to be subjected to tests, that they regarded it as an imposition on their honesty, and that they would not receive the oil back again. A little firmness on the part of the Purchasing Agent resulted in their sending for the oil. One week after that they wrote a letter stating that they would be glad to send another 100 barrels in place of the 100 barrels rejected. The Purchasing Agent replied that they might send the material, subject to test at Altoona. If the oil passed test, the company would take the oil and be glad of it ; if not they must take it back again. The shipment was made under these conditions, and on examination proved to be as fine a grade of extra lard oil as it has ever been our fortune to test. The commercial side of this case is interesting. The bill for this oil was $5,050 ; our subsequent experience makes us feel certain that the adulterant used in this case was cotton-seed oil, which at that time was 55 cents per gall. The shipment by our test, therefore, contained 1,250 galls. of oil having a market rate of 55 cents per gall., and 3,750 galls. of oil having a market rate of $1.05. Each gall. of the adulterant, therefore, afforded a clear profit of 50 cents, or the net fraud on the purchaser in this transaction was $625.00.

Since those early days of contest over cotton-seed oil, the relative prices of lard oil and cotton-seed oil have approximated each other, until now there is not much difference, and therefore there is not as much temptation to mix cotton-seed oil with lard oil. It is impossible, of course, for us to say what oils are offered those companies who have no laboratories and who do not have their supplies tested in any way. We have occasionally been appealed to by officers of other railroads to decide questions in regard to shipments, and have found in almost every case that the disposition to mix cheaper with better oils has not entirely ceased.

In addition to the petroleum products and cotton-seed oil, which are the most common adulterants, it is not impossible that any one of the following oils may be found in the market mixed with lard oils, viz. : Resin oil, peanut oil, corn oil, fish oils, especially menhaden, black fish, sea elephant, and the cheaper porpoise and whale oils, also the cheaper grades of olive oil, neat's-foot oil, tallow oil, colza oil, and mustard-seed oil. Nearly all of these oils have been brought to our attention and have been studied more or less during the past 14 years. Most of them, except resin oil, are so near the price of the lard oils, or their admixture with the lard oils is so easily detected, that serious adulteration by means of them is at present improbable. A change in the abundance of the supply of any of them, causing a marked drop in price, or improved methods of



treating many of these oils, making their detection in mixtures less easy, may, however, occur at any time, and there is therefore no safety except a test of every shipment and constant watchfulness on the part of an able chemist.

In the next article of this series we will consider the specifications for Lard Oils, now in force on the Pennsylvania Railroad, and the methods of testing adopted.

(TO BE CONTINUED.)

THE USE OF WOOD IN RAILROAD STRUCTURES.

BY CHARLES DAVIS JAMESON, C.E.

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(*Continued from page 29.*)

CHAPTER XX.

PILE ABUTMENTS AND PIERS.

BEFORE taking up the subject of Wooden Bridges in all its details, we wish to call attention to a class of structures upon which for many years these wooden bridges rested —that is, Pile and Timber Abutments and Piers.

All the earlier bridges rested upon either piles or cribwork filled with stone, and it is only within a few years that stone foundations have been carried to any depth below the water.

Upon new roads and in thinly inhabited countries, where wood is easily obtained of a good quality, this same method of supporting short-span bridges can be and is still used with an economical result.

Such structures are open to the two great objections inherent in the use of wood, and these are—Fire and Decay. In this case, however, the inevitable decay is the more important, as under ordinary circumstances the danger from fire is very slight.

Plates 79, 80, and 81 show the standard plans of these structures as used upon the Atchison, Topeka & Santa Fé Railroad.

Up to a height of 30 ft. above the ground the piles themselves may be used as a framework for the structure, but above this height, or even 5 ft. to 10 ft. below it, it is often more secure and more economical to cut the piles off some 2 ft. or 3 ft. above the ground and to secure a good foundation by drift-bolting caps to them ; then upon the caps building a special frame with plumb-posts, batter-posts, etc., upon the same principles that have been laid down for framed bents, etc.

In all of these structures especial attention must be paid to the thorough spiking or bolting of every piece to its place. Whether the piles themselves are used as a frame, or a special frame is built resting upon the piles, the outside of this frame should be carefully planked with 4 in. oak plank to a point above high-water line and above the ice-line. The plank should be boat-spiked to each pile.

When the piles are used as a frame, there should be a timber about 8 in. × 10 in. run around upon the inside, near the top of the piles, and bolted to each pile by a bolt not less than ¾ in. in diameter. When the piles extend anywhere near 30 ft. above the ground there should be several of these stiffening timbers used, spaced at proper intervals between the ground and the top of the piles.

As will be seen by an examination of the plates, there are usually two rows of piles. Upon the top of these piles, and running at right angles to the line of track, are bolted double caps, the top one being 8 in. × 12 in. in size and of oak. Upon these caps rest the blocks, bolsters, etc., which support the bridge proper.

Plate 79 shows plans of a pile abutment without approaches. This plan should never be used excepting under circumstances which make it impossible to use the plan shown in Plate 80. Always, when it is not absolutely impossible, pile or trestle approaches should be used to all wooden abutments.

Plate 81 shows a plan of a pile pier. In this, as in the abutment, the piles can be carried up to serve as a frame, or they may be cut off and serve only as a foundation to a special frame. The main part of the pier consists of four rows of piles, spaced 2 ft. 8 in. from center to center, the

PLATE 81

A. T. & S. F. R. R

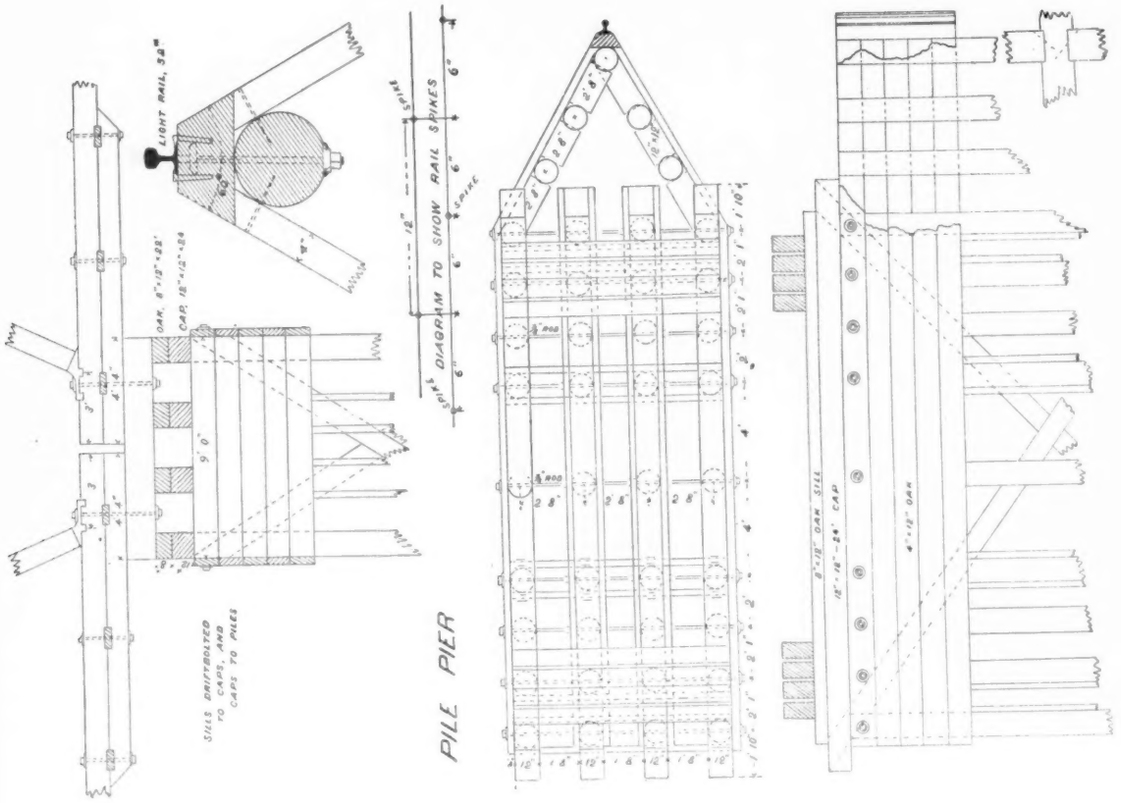


PLATE 80

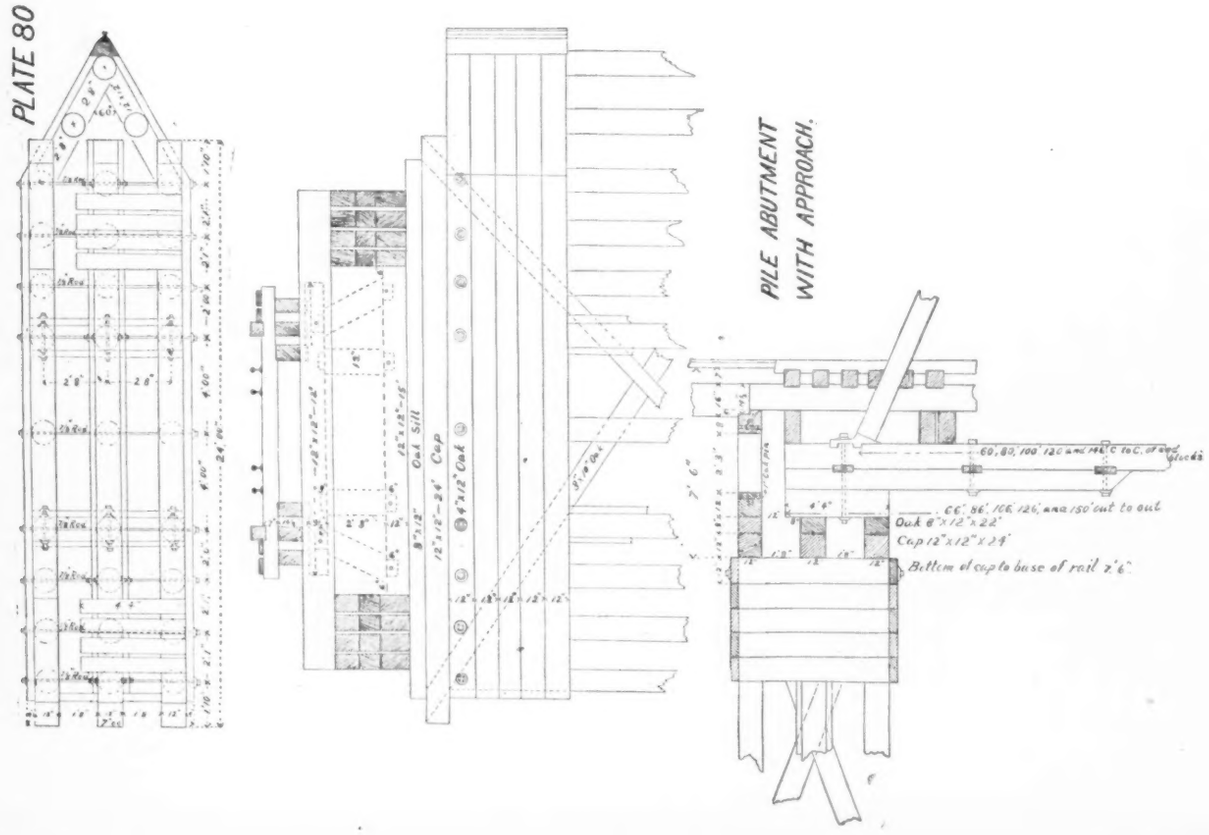
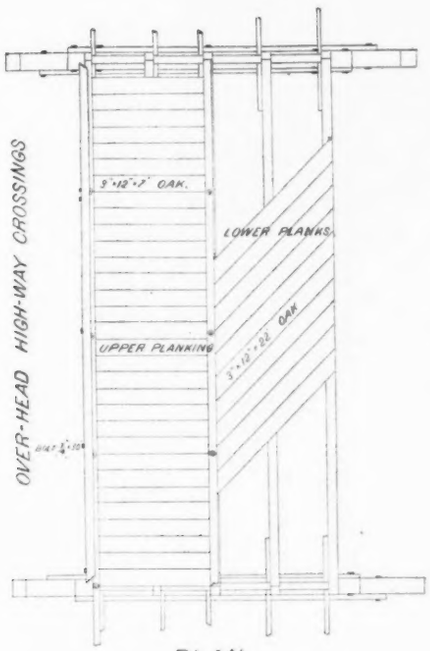

12"x12"-24' Cap
8"x12" Oak
8" 12" Oak Sill
PILE ABUTMENT WITH APPROACH.
60, 80, 100, 120 and 140 C to C. of end floods
CC. 86', 106, 126, and 150' out to out
Oak 8"x12"x22'
Cap 12"x12"x24'
Bottom of cap to base of rail 2'6"

PLATE 86.

A T & S F R R

OVER-HEAD HIGH-WAY CROSSINGS



PLAN

No 2 ROAD CROSSING

DETAILS OF HAND RAIL POST

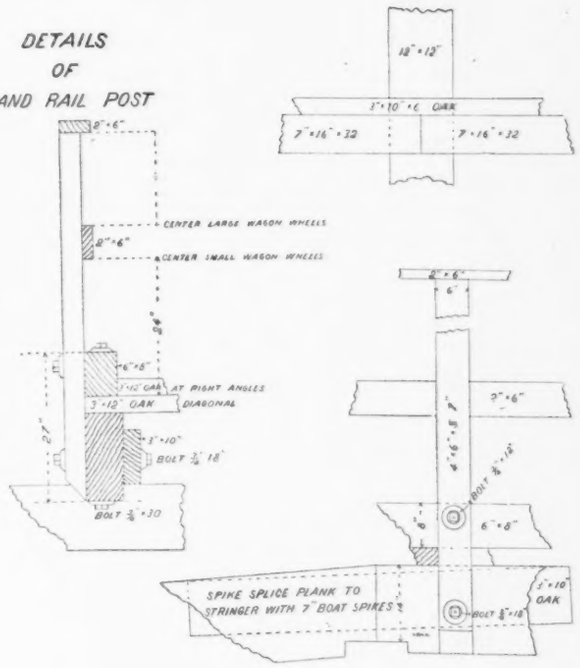
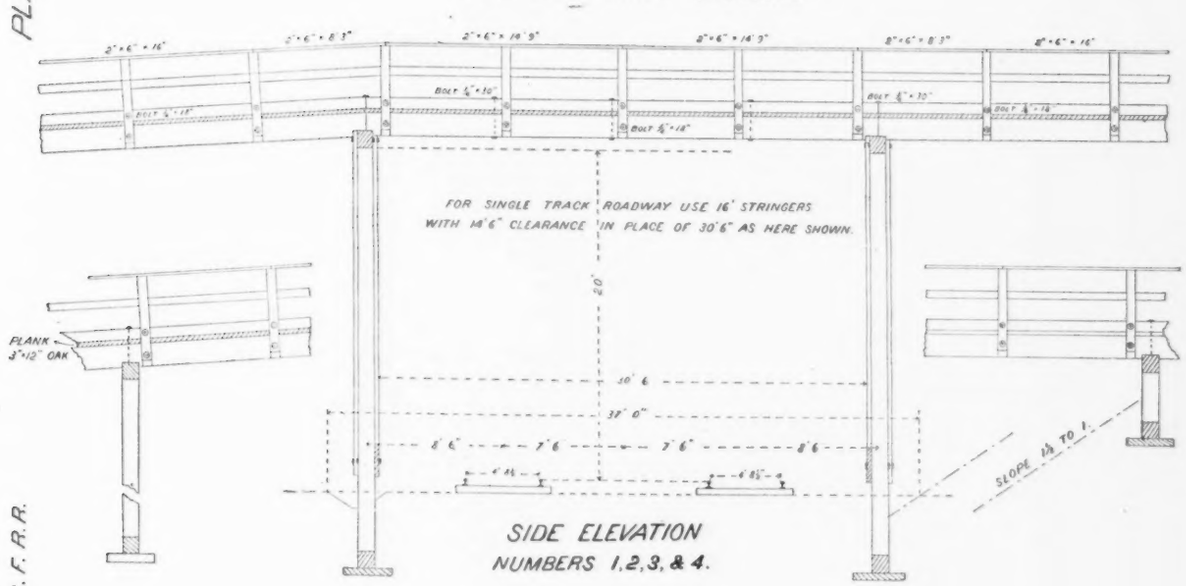


PLATE 83.

A. T. & S. F. R. R.

OVER-HEAD HIGHWAY CROSSING



SIDE ELEVATION

NUMBERS 1, 2, 3, & 4.

spacing of the piles in the rows being as shown in the plan. The longitudinal and lateral cross-bracing is shown clearly in the plate, and the outside is planked with oak plank, 4 in. × 12 in. in size, boat-spiked to each pile. Upon the up-river end is built the "nose" or "ice-breaker." The details of this are fully shown in the plate.

The nose should be thoroughly braced at the high-water line and also at the ice-flow line by 12 in. × 12 in. pieces set between the piles and notched into them about 1½ in., as shown in fig. 3. These pieces should also be held in place by spikes driven through the outside planking. The stringer on the point of the nose should be bolted to the pile at intervals of 4 ft. with ¾-in. bolts. The rail used as a fender may be of any size most convenient. On the Atchison, Topeka & Santa Fé Railroad a 52-lb. rail is usually used. This rail should be spiked to the stringer, as shown in the diagram, every 12 in. on each side, and the spikes placed alternately. The holes for these spikes, and all the spikes used, should be bored with a ½-in. bit.

In the plans shown in the plates the bottom of the cap is always 7 ft. 6 in. below the base of the rail.

In both pile-piers and framed piers upon piles, the interior should be filled in as much as possible with stone after the track is laid. The nose and that part of the pier extending back to the point marked *A* should certainly be carefully filled with stone.

CHAPTER XXI.

OVERHEAD CROSSINGS AND BRIDGES.

On every railroad there will be required a number of small structures for overhead crossings, and in many cases it will be necessary, on account of economy, to construct these of wood. Even on the more important lines there are by-roads and farm-crossings where an expensive structure is not warranted by the nature or importance of the traffic, and where a wooden bridge will answer every purpose.

Plates 83, 84, 85, and 86 show overhead crossings of this kind as constructed on the Atchison, Topeka & Santa Fé Railroad. The general plan and details of these structures are shown very fully in the plates, and will require but little additional description. Of course this class of bridges will vary in different places, according to the surroundings and local needs, but the general type will remain substantially the same.

(TO BE CONTINUED.)

UNITED STATES NAVAL PROGRESS.

NOT much is to be said of new ships yet, as at present everything waits upon the action of Congress. Judging from the general temper of that body, however, it seems very probable that the recommendations made by the Secretary will be met, in part at least, and a liberal appropriation for new ships made.

It may be noted that the four new cruisers included in the Squadron of Evolution—the *Chicago*, *Boston*, *Atlanta*, and *Yorktown*—did well on their first voyage, and showed themselves to be excellent sea boats in a very stormy passage across the Atlantic.

Rapid progress is being made in fitting out the *Charleston* and the *Baltimore*, and those ships will soon be added to the list of our active Navy.

THE NEW ARMORED CRUISERS.

A circular has been issued by the Navy Department, addressed to the ship-builders of the country, on the subject of the 5,300-ton cruiser and the 7,500-ton armored cruiser. This circular appears in advance of the regular invitation for proposals, and is intended to convey to possible bidders such information regarding these vessels as will enable them to make up their own plans and specifications for submission under the terms of Class 2.

The circular prescribes for the 5,300-ton steel cruiser, which is to cost not more than $1,800,000, a maximum speed of at least 20 knots per hour, and allows a premium of $50,000 for every quarter of a knot over the guarantee, and deducts from contract price $50,000 for every quarter of a knot less than the guarantee. The main battery is to consist of two 8-in. breech-loading rifled guns, to be mounted in a barbette or casemate, with armor 4 in. in thickness, protected by a steel circular shield 4 in. in thickness, secured to the gun platform and revolving with it on a circular roller base, and ten 4-in. rapid-fire guns to be mounted under the protection of the superstructure deck, having semi-circular shields on them, which revolve with and keep the port nearly closed. At the ship's side above and below these guns further protection is had by steel plates 4 in. in thickness. The secondary battery consists of eight 6-pounder Hotchkiss, six 3-pounder Hotchkiss, two 1-pounder Hotchkiss, one 1-pounder boat mount, four 37 mm. caliber Maxim guns, six 45 mm. caliber Maxim guns. The coal supply is 1,300 tons, and the coal supply at normal displacement 400 tons. The complement is to be 25 officers and 441 men. The thickness of armor on slope over machinery is 4¾ in.; thickness of armor on flat over machinery, 2 in.; thickness of armor on slopes at ends, 3 in.; thickness of armor on flats at ends, 2 in. The total weight of main battery and ammunition is 84.42 tons; the weight of the secondary battery is 16.60 tons, and its ammunition, 39 86 tons; the weight of small arms and equipment 3.70 tons and its ammunition 10.84 tons, making total weight of armament and protection 434 tons. The electric light plant will consist of three units, each unit to have an engine, dynamo, and combination bed-plate, the combined weight of which should not exceed 2,400 lbs. The weight of all stores and fittings of the installation, including search-lights, should not exceed 30 tons.

The armored cruiser of 7,500 tons displacement, to cost not more than $3,500,000, is to exhibit a speed of 17 knots per hour. The armament of the main battery is to consist of four 11-in. breech-loading rifled guns and six 4-in. rapid-fire guns. The secondary battery is to consist of four 15-pounder Hotchkiss, four 6-pounder Hotchkiss, four 3-pounder Hotchkiss, four 1-pounder Hotchkiss, four 37 mm. caliber Maxims, four 45 mm. caliber Maxims. The coal supply is to be 1,000 tons, and at normal displacement 450 tons. The complement of the vessel is to be 25 officers and 416 men. The side armor is to be 11 in. in thickness; protection of great guns, 10.5 in.; diagonal bulkheads, 10 in.; conning-tower, 10 in.; protective deck over building, 3 in.; protective deck at ends, 2 in.; protection of auxiliary battery, 4 in. The weight of main battery will be 279 tons and its ammunition 231.04 tons; of the secondary battery, 25.80 tons, and its ammunition, 56.35 tons; of small arms and equipments, 4 tons, and its ammunition, 11.60 tons. The torpedo outfit consists of 21 Howell torpedoes, 6 launch tubes with engines, connections, etc.; 1 boat torpedo outfit, torpedo defense net, torpedo bombs, having a combined weight of 683.29 tons. The equipment outfit will weigh 238.36 tons. There are to be three complete generating sets in the electric light plant of the vessel.

These will be the first vessels armed with the Maxim gun.

Since the issue of this circular the Secretary has ordered work to be suspended on the plans of the 7,500 ton ship to allow time for Congress to authorize her increase to an 8,500 or 9,000-ton vessel. No detailed plans of the enlarged ship have been worked out yet, and it has not even been decided what type she is to be. It is most probable, however, that she will be given more armor protection and heavier guns, her 11-in. guns being supplanted by guns of 12-in. caliber. The secondary battery of rapid-fire guns would also be increased and more engine power would be given her, so as to force her speed up to 18 knots or more and make her a fast-cruising battle-ship. Another proposition is to convert her into a protected cruiser of great speed equal to or superior to the *Blake*, of the British Navy. If this plan is adopted, side-armor will be dispensed with entirely, and her vital parts will be protected by a heavy turtle-back steel deck, sufficient to deflect most of the shots that would be apt to strike her. The lines of her hull would be designed for great speed, and she would be given engines of from 13,000 to 14,000 H.P., so as to drive her through the water at a maximum speed of from 20 to 21 knots an hour. If this latter type is adopted, the

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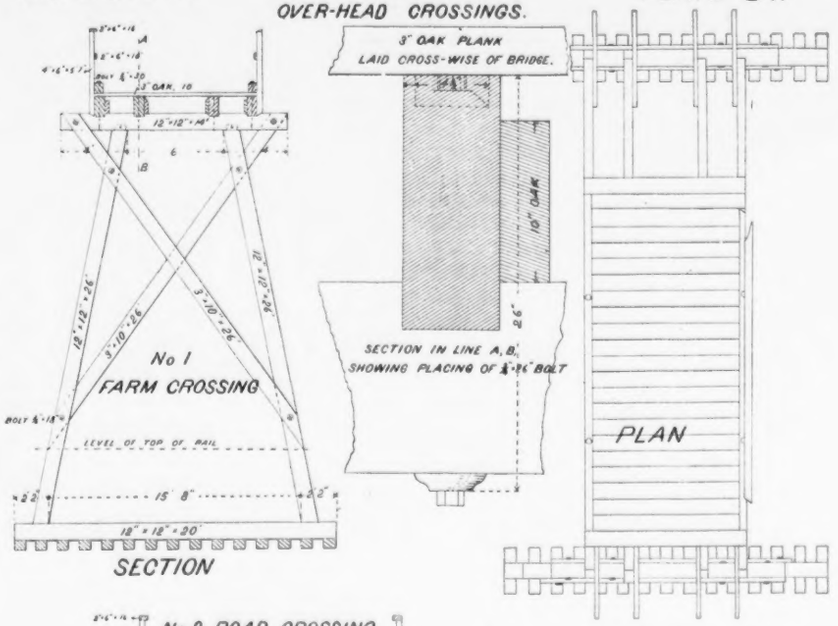
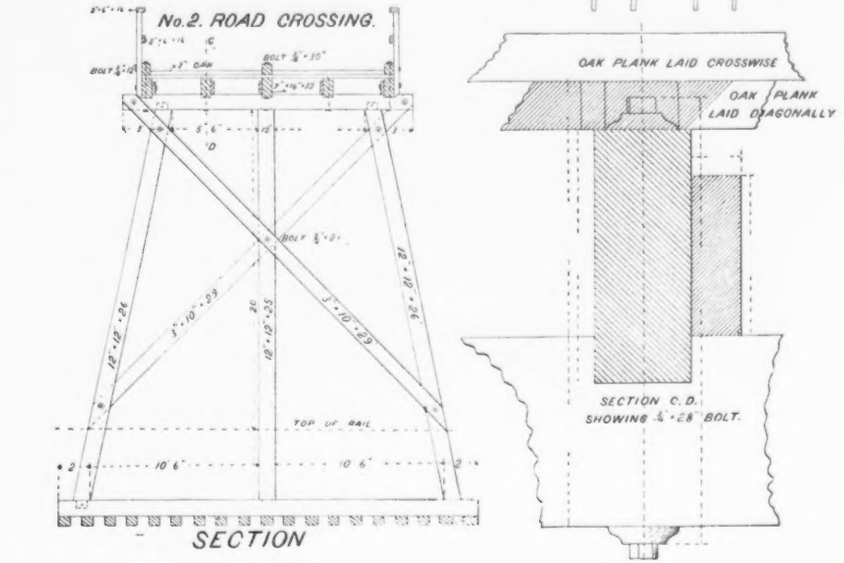
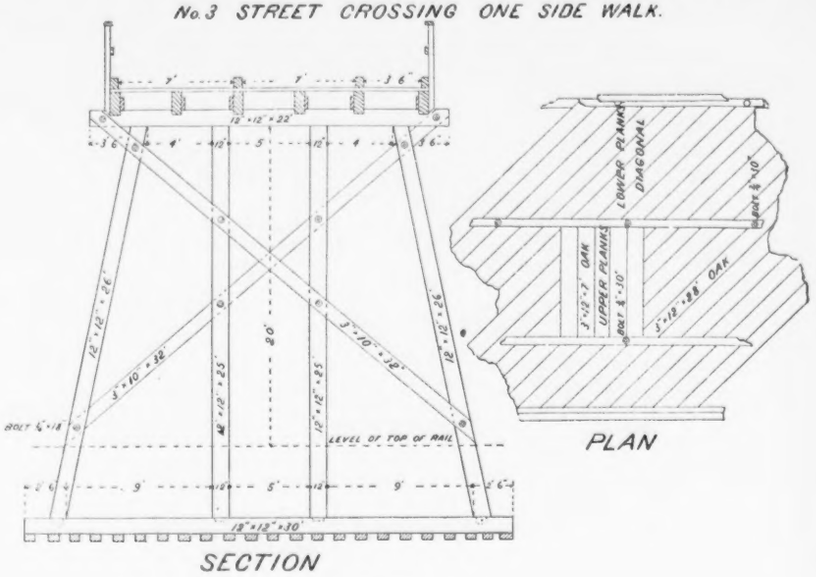
A. T. & S. F. R. R. PLATE 84.

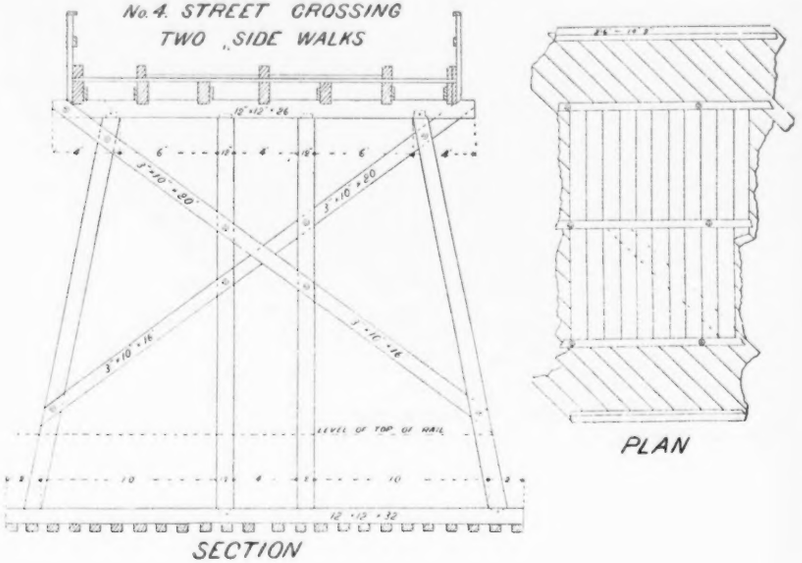
OVER-HEAD CROSSINGS.





A. T. & S. F. R. R. PLATE 85





weight of the vessel's battery will be greatly reduced, and Instead of four 11-in. guns her largest weapons will probably be two 10-in. guns.

THE NEW TORPEDO-BOAT.

The torpedo-boat *Cushing*, built by the Herreshoffs at Bristol, R. I., is required by contract to make 22 knots an hour. The builders will receive a premium of $1,500 for each quarter-knot up to 24 knots which the vessel may make, and $2,000 for each quarter-knot over 24 knots, should that speed be exceeded.

The boat is 138 ft. long, 15 ft. beam, 10 ft. deep and 4 ft. 4 in. draft; it is built entirely of steel. The armament will consist of two 14-in. torpedo-tubes at the bow, with two other torpedo-tubes and two small rapid-fire guns on deck.

The boat has two screws, each driven by a separate engine. These engines are of the quadruple-expansion pattern, with five cylinders. The high-pressure cylinder is 11¼ in. in diameter; first intermediate cylinder, 16 in.; second intermediate cylinder, 22 in.; two low-pressure cylinders, each 22 in.; all being 15-in. stroke. The propellers are of manganese bronze, 4 ft. 2 in. in diameter and 8 ft. pitch. Steam is furnished by two Thornycroft water-tube boilers, built by the Continental Iron Works, of Brooklyn, N. Y. Each boiler has 34 sq. ft. grate surface and 1,800 ft. heating surface. Forced draft will be supplied by a fan-blower. There is an electric light plant for lighting the boat and for search-lights.

THE NAVAL RESERVE.

An abstract of the important bill introduced in the Senate by Mr. Frye, of Maine, to provide for the establishment of a reserve force of cruisers for the Navy is as follows:

"The Postmaster-General is authorized to enter into contracts for a term of years, not less than five nor more than ten, for the carrying of the mails between the ports of the United States and foreign ports in iron and steel American owned and built steamships. The service is to be let to the lowest bidder. These steamships shall be officered by American citizens, manned by crews at least one-half of whom shall be American citizens, and constructed after the latest and most improved models. The steamships will be of two classes. The first shall be iron or steel screw steamships, with a speed of at least 18 nautical miles an hour, and a gross registered tonnage of not less than 4,000 tons; and no vessel except of the first class shall be accepted for mail service between the United States and Great Britain. The second class shall be iron or steel steamships, not less than 2,000 tons gross, capable of a speed of 14 nautical miles an hour.

"All steamships hereafter built for this purpose shall be constructed on models and according to plans and specifications approved by the Secretary of the Navy, and of sufficient strength and stability to carry and sustain the operation of at least four effective rifled cannon of a caliber not less than 6 in., to be specially adapted to conversion for use as transports or cruisers in the event of war. The compensation for mail service by the first-class ships shall not exceed $6 a mile for outward voyage, and for the second class ships not more than $4 a mile. A United States mail messenger shall be transported on each ship free of charge, with the usual cabin accommodation, to receive, take in charge, and deliver the mails. Officers of the Navy may, with the consent of the Secretary, be granted furlough and accept employment on these ships, receiving as pay furlough pay and such additional amount as the contractor and the officer may agree to.

"Each of these ships shall take an American-born boy as cadet or apprentice for each 1,000 gross register tons and one for each majority fraction, who shall be ranked as a petty officer, trained as a sailor, and receive reasonable pay for his services. In event of war such steamers may be taken by the United States for use as transports or cruisers, upon payment to the owners of the value of the same, to be ascertained by appraisal."

ORDNANCE AND ARMOR-PLATES.

The Secretary of the Navy has issued advertisements asking bids for supplying eight 16-in. gun-lathes for the Naval Ordnance Foundry in the Washington Navy Yard. Bidders may submit proposals for lathes constructed in accordance with the plans of the Bureau of Ordnance, or they may submit designs of their own. These lathes will be an immediate addition to the plan of the Ordnance Bureau. Thus far it has not been possible to handle guns of over 10-in. caliber in the Washington Yard, but the new lathes and the 110-ton traveling crane now under construction will make it possible to finish guns up to 16-in. caliber. Forgings are now coming in under the contracts made some time ago, and it is understood that there will be no difficulty in supplying the guns for the new vessels as fast as they are wanted.

The Navy Department has also given notice of competitive trials of armor-plates to be held at the Naval Proving Grounds at Annapolis, and manufacturers are invited to submit plates for trial. This must be 6 ft. by 8 ft. in size and 10½ in. in thickness. Manufacturers desiring to compete must notify the Department of their intention to do so not later than February 10 next.

HORATIO ALLEN.

HORATIO ALLEN, who for more than half a century has been known as a distinguished engineer, died on the evening of New Year's Day at his residence, "Homewood," near South Orange, N. J. For nearly a year he had been confined to his house by the infirmities of age, and, at last, when the vital forces had been transformed into the work of a lifetime, his days were ended peacefully, and his eventful career was finished.

He was born in Schenectady, N. Y., in 1802, and was consequently 86 years old last year. He was the son of Dr. Benjamin Allen and Mary Benedict Allen. His father was the principal of a large school at Hyde Park, N. Y. The son therefore had excellent educational advantages in early life, and was sent to Columbia College in New York City, from which he graduated about 1820, taking high rank in mathematics. He studied law at first, but after a short time decided to make engineering his work, and entered the employment of the Delaware & Hudson Canal Company under Judge Wright, then Constructing Engineer of the line. In 1824 he received an appointment on the Chesapeake & Delaware Canal. He was sent to St. George's, Del., and within two weeks was placed in full charge of a party. In the autumn of 1824 he was made Resident Engineer of that work. A year later he was appointed Resident Engineer of the summit level of the Delaware & Hudson Canal, under John B. Jervis, then Chief Engineer of the Company. While Mr. Allen was engaged in this position his attention, and that of other engineers in America, was attracted to the performance of locomotives in England. His early relation to these events may best be told in his own words, quoted from a pamphlet, with the title "The Railroad Era," which he published a few years ago. In this he said:

"During the years 1826 and 1827 the use of the locomotive on the Stockton & Darlington Road, England, had become known to many, and especially to civil engineers in this country, and among others to myself, then a Resident Engineer on the line of the Delaware & Hudson Canal, the great engineering enterprise of the time, the first of the great works, canal and railroad, that were to bring the anthracite coal of the valley of the Susquehanna into the valleys of the Delaware and of the Hudson and to the ocean.

"Such consideration as was within my power led me to a decided conviction as to the future of the locomotive as the tractive motive power on railroads for general freight and passenger transportation, as it had begun to be for mine transportation. . . .

"Early in the year 1827 I had given all the attention that it was in my power to give, and having come to conclusions as to the locomotive, that all subsequent experience has confirmed, and believing that the future of the civil engineer lay in a great and most attractive degree in the direction of the coming railroad era, I decided to go to the only place where a locomotive was in daily operation and could be studied in all its practical details.

"Closing my service on the Delaware & Hudson Canal, some two months were appropriated to certain objects and

interests, after which I was again in New York, preparatory to going to England.

"On my return to New York from these visits, I found that it had been decided by the Delaware & Hudson Canal Company to intrust to me, first, the having made in England for that Company the railroad iron required for their railroad. . . .

"This action of the Delaware & Hudson Canal Company was on the report of their Chief Engineer, John B. Jervis, and thus it occurred that the first order for a locomotive engine, after the locomotives on the Stockton & Darlington Road were at work, came from an American company, on the report of an American civil engineer."

The following are copies of some old papers, which were preserved by Mr. Allen, relating to this commission. One of them is indorsed :

"1828.--EXTRACTS FROM THE REPORT OF THE COMMITTEE SANCTIONED BY THE BOARD REFERRED TO IN MY LETTER TO MR. ALLEN.

"J. BOLTON, *President.*"

The following is a copy of the paper which evidently embodies the instructions of a committee to Mr. Allen for the execution of his commission in England :

EXTRACT, ETC.

That Horatio Allen, Esq., Civil Engineer, has agreed to go to England as the Agent of the Company to procure the railroad plates and perform such other services in relation thereto as may be required of him. The Company to pay his passage out and home and his expenses during his stay, allowing him to remain three months, for the purpose of attending to the Company's business and acquiring information. His expenses on the whole not to exceed $900, and on his return he will communicate to the Company all the information he may acquire that may be useful to the work in which they are engaged.

That they deem it advisable to authorize Mr. Allen to procure one locomotive engine complete, as a pattern, and that the Chief Engineer is making inquiries to ascertain whether it may not be expedient to authorize the construction of all the locomotive engines in England.

That it is deemed advisable to suspend the making of the wheels and axles of the coal wagons until information be received from Mr. Allen of the cost of those articles in England, and of the latest improvements that have been adopted in the manner of connecting the wheels and axles. The engineer in his report recommends wheels of 3½ ft. diameter ; but his mind is not definitely made up on this point. He will investigate the matter further and report the result.

That Mr. Allen be instructed to procure the railroad plates of the length recommended in the report of the Chief Engineer ; the ends to be cut and fitted into each other and the holes made for the fastenings, as recommended in the same report ; that the rounding of the edges of the plates will be advantageous, but is not so indispensable as to induce the committee to recommend that the plates be thus formed without limitation as to the increase of expense and time that may be required therefor.

That there is much force in the reasoning of the Chief Engineer in favor of dispensing with any allowance for expansion and contraction of the plates, in forming the holes for the fastenings, yet the committee are of opinion that it would be safest to make such allowance, and the Chief Engineer has devised a plan for effecting it which the committee believe will be successful. This plan will be communicated to Mr. Allen and he may then be allowed very safely to adopt that or any other plan which may be found more economical.

The committee being now satisfied that an economical plan will be devised for forming the holes in the plates so as to allow for contraction and expansion, they unite in opinion with the Chief Engineer that the fastenings of the plates will be best effected with screws.

That the Chief Engineer is of opinion that on two of the levels west of the summit and one east of the summit machinery worked by engines may be advantageously substituted for the horse-power first proposed, but that the form of the country will not admit of such substitution on the other levels west of the summit.

EXTRACT FROM THE MINUTES OF JANUARY 10, 1828.

S. FLEWELLING,

Treasurer of the Delaware & Hudson Canal Company.

The rounding of the edges or omitting it is left to Mr. Allen. The last paragraph is introduced to suggest to Mr. Allen that information is wanted. In the letter to Messrs. Brown, I say :

"Mr. Allen is authorized to procure such drawings of machinery and designs connected with railroads, canals, and the raising and transporting of coal as he may deem proper."

J. BOLTON.

A letter from Mr. Jervis, the Chief Engineer, which apparently accompanied the preceding "Extracts from the Report of the Committee," is endorsed :

"1828.—MR. JERVIS'S LETTER TO MR. ALLEN REFERRED TO IN MY LETTER TO MR. ALLEN.

"J. BOLTON."

The letter is as follows :

To Horatio Allen, Esq.

DEAR SIR : The Board of Managers for the Delaware & Hudson Canal Company, having made an engagement with you to proceed to England as their Agent to procure certain articles for the proposed Carbondale Railroad, and also such information as may be useful in the construction and management of said railroad ; I am therefore directed by the said Board of Managers to furnish you such information and instruction as will further their object.

The Board of Managers have determined on procuring their iron plates for the railway tracks as one item.

The length of plates to be from 12 to 14 ft., as you may find most convenient for rolling them through on the edges ; to be 2½ in. wide on the bottom and 2 in. on the upper surface and ½ in. thick, with the upper edges rounded and the end finished as represented on the plan. Holes to be drilled for the screws with countersunk heads at each end of every bar and at intermediate points 18 in. apart. After the holes and countersink have been drilled in a circular form, then a rimmer of the proper form to fit the countersink and hole for the neck of the screw to be put in to cut the aperture longitudinally. To effect this the rimmer must be put in and then firmly fixed to its position and the bar made to move toward it in the direction of its length, about ⅛ or ⅛ of an inch. This may be reduced as you recede from its end to the center ; but as it is likely to create confusion to attempt any economy in varying the length to be rimmed, it will be better to have all the holes rimmed alike.

LOCOMOTIVE STEAM ENGINES.

It is desirable, in order to dispense with the tender carriages, to have a water tank fixed to the engine carriage that will contain about 100 gals. If made in two parts, of sheet-iron, it will weigh, with its hanging or supporting irons, about 250 lbs., and the water about 1,000 lbs., making together about 1,250 lbs. To increase the capacity of the tank to 120 or 150 gals. would add but little to its weight. I see no difficulty in attaching such a tank to the engine carriage, and you will determine whether it will be most convenient to support it over the axles or suspend it under them ; being divided into two equal parts it may be placed on each side of the revolving chains, with a pipe to pass the water from one to the other. If the weight of the engine should admit of it, it will be preferable to make the tank sufficient to contain 120 to 150 gals. The pump of the engine to supply the boiler with water from the tank should be calculated to work one-quarter faster than necessary for a regular supply in order to provide for a waste of steam when the engine stops, and to be constructed so as to work by hand, which will be necessary at certain times. The boiler will not require a capacity for any considerable quantity of water beyond what is necessary for the work, as the pump will regularly supply, except when the carriage stops at the end of the road, at which time it is supposed to have supplied a surplus adequate to the waste that will take place during delay. The stoppages may be estimated at one-quarter the whole time ; on the shortest section 10 minutes, on the longest 20 minutes. The weight of engine, carriage, and water, if placed on six wheels, to be from 6 to 7 tons, but 6½ tons preferred. If it should be found that a six-wheel carriage has any important difficulty in working well on curved roads, that in your judgment would counterbalance the advantage of a heavier engine and give the preference to the four-wheel carriage, then the weight must not exceed 5½ tons ; but the six-wheel carriage will be preferred if it can be made to work. If a six-wheel carriage the axle need not exceed 2¾ or 3 in. at the bearing. The diameter of the wheels 3 to 4 ft., as you find most approved from experiments in England for similar purposes and rate of traveling, say 3½ to 5 miles per hour. The power of the engine, such as will carry 800 lbs., at the rate of 4 miles the hour, or what is nearly the same thing, 640 lbs. at the rate of 5 miles the hour. I think about 4 miles the hour a good velocity for the work contemplated, but the range above given will allow you to vary this, as you may find most expedient, in relation to several points that you will perceive to have a bearing on this question. The diameter of the wheels of the engine carriage will affect the velocity, or distance

traveled at a given number of strokes of the engine, but I would take 3 ft. as the minimum diameter and make them as much larger as the arrangement of the working parts will admit, without giving too great a velocity. The length of the stroke must depend something on the facilities of securing firmness to the cylinder, and this may lead you to prefer a larger or smaller diameter for the cylinder; the pressure of the steam has also a bearing on the question; on account of the weight I think the cylinder should not exceed 8 in.

To elucidate my views more fully, I will state what appears to me a suitable arrangement. Length of stroke 27 in. and 40 strokes per minute; two 8-in. cylinders, pressure of steam 60 lbs. per square in. This will give 2,400 revolutions per hour. Area of cylinder $8^2 \times .7854 \times 2 = 100.5$ sq. in. A double stroke equal 4.5 ft.; then $100.5 \times 4.5 \times 60 \times 2{,}400 = 65{,}124{,}000$ lbs. raised 1 ft. But by the experiments of Wood we may only take 30 per cent. and $65{,}124{,}000 \times .30 = 19{,}537{,}200$ raised 1 ft., which is equivalent to 800 lbs. carried or raised 24,421 ft., equal to 4.62 miles per hour. Now $24{,}421 \div 2{,}400 = 10.17$ ft., the space moved over by the carriage at each revolution of the engine, and of course the diameter of the wheel must be 3.25 ft. If there should appear a difficulty in securing a cylinder with proper stability for the above length of 27 in., it may be advisable to make the stroke 25 in. Then, all other points remaining the same, the power of the engine will only be equal to carry the same load of 800 lbs. 4¼ miles, and the wheels of the carriage must be reduced to 3 ft. diameter. It may be found expedient to have larger wheels and travel at the rate of 5 miles per hour, with a proportional load. Suppose cylinder 7½ in. diameter, 27 in. stroke, pressure 60 lbs., 40 double strokes per minute, or 2,400 per hour. Then $7.5^2 \times .7854 \times 2 = 88.34$, say area of two cylinders $88 \times 60 \times 4.5 \times 2{,}400 = 57{,}224{,}000$ lbs. raised 1 ft.; 30 per cent. is 17,107,200 lbs. raised 1 ft., and is equivalent to 648 lbs. carried 5 miles, will require the carriage-wheel to be 3½ ft. diameter. The power of the engine will be a trifle less than the last calculation before it. But if you find it necessary to reduce the length of stroke to 25 in., it will not give the power we prefer with less than 8-in. cylinders. If, as before observed, you find difficulties that have not been anticipated in working a six-wheel carriage, that compels the use of a four-wheel carriage, the power of the engine must be reduced in order to reduce the weight of the engine and the carriage. If you can avoid it, I think it better not to calculate for more than 40 double strokes per minute. I believe the above will give you a sufficient view of what will answer our object, and you must vary as you find the experience of England and your own judgment may direct. I am of opinion that the furnace had better be of the oval form laid flat, otherwise the furnace may be the same as for bituminous coal. It is supposed anthracite coal does not require so high a chimney as other fuel, but I am not possessed of any particular facts on this subject; I presume you can have the chimney so constructed that an additional piece may be attached if it is found on trial to require it. On this presumption I would not have it more than 10 ft. high. As the height of chimney will affect the calculai on of bridges, it is advisable to understand this question as early as possible.

The width in the clear between the rails is 4 ft. 3 in. The greatest curvature of that part of the road on which locomotive engines are to be used is that which gives a versed sine of 1 ft. on a chord of 59 ft.; but there is only a single instance of this curvature, arc of 15 chains. The curvature which occurs in several instances is a versed sine of 1 ft. on a chord of 66 ft. A 10-ft. chord exactly ⅛ in.

It is determined by the Board that you will procure from England one locomotive engine with carriage complete for work. The three others that will be wanted to depend on the cost at which they can be obtained and delivered at New York. It is supposed that they can be obtained of American manufacturers for $1,800, and I presume it will not be economy to procure them from England at a greater cost, unless you perceive a superiority in the workmanship of English engines that in your opinion will justify the additional cost.

As a preliminary step I should advise, previous to the purchase of the locomotive steam engine, that you visit the Killingworth Railroad near Coventry, the Hetton Railroad, and Darlington & Stockton Road; the two latter are near Sunderland. At Killingworth the locomotive engine is said to have been in regular use (working by the adhesion of the wheels) since the year 1814; but the Hetton Road is more in the character of the proposed work.

Although I am strongly of opinion that this will be the most convenient and economical power for the contemplated railroad, still you will perceive the propriety of availing ourselves of the experience of others in reference to its actual utility. If on examination you should find essential difficulties that we have not apprehended in the use of this means of transportation, and such as in your judgment would counterbalance their advantages, then it will be advisable not to make an engagement, but to communicate the result of your observations as early as possible.

RAILROAD CARRIAGES.

Inquire respecting the relative advantages of the fixed and revolving axle of common railway carriages; their operation on curved roads; the methods and facility of applying the brake; the manner of constructing and securing the axle to the wheel in both cases; facilities for oiling; the width of rim or track of wheels as compared to the width of rail; thickness, depth of projection and form of flange; breadth and thickness of spokes of cast and wrought iron; manner of handling and fastening the door in the bottom of the carriage to facilitate unloading coal.

It is deemed advisable to ascertain the cost of iron axle trees for the coal carriages made of iron equal in quality to Swedes or Russia iron, the bar 2½ in. square and the bearing 2½ in. diameter turned smooth. State the cost distinct for revolving and fixed axles; as you will perceive, the fixed axle will, on account of its longer bearing in the nave of the wheels, require more expense in turning. Examine whether fixed axles are tapered from the shoulder to the outer bearing in the nave, or whether the axle is of uniform diameter through the nave of the wheel, and in what manner the wheel is secured to the axle, and box of carriage through the axle.

Very respectfully, your friend and obedient servant,

JOHN B. JERVIS.

NEW YORK, January 16th, 1828.

The duties, say 27½ per cent., exchange, interest, and other charges, will together amount to about 45 per cent. on the cost of the engine.

"It was under these favorable circumstances," Mr. Allen says, "that I left New York in January, 1828, and within two days after my arrival at Liverpool I made the acquaintance of George Stephenson, in the most agreeable relations, and from that time, during my stay in England, I received from him every kindness in his power, and all the aid to what I had come so far to seek that was at his command at Liverpool on the Stockton & Darlington Railroad and at Newcastle, at that time the center of all that was in progress in railroad and locomotive matters."

To get an idea of "the state of the art" of locomotive construction at the time Mr. Allen arrived in England, in 1828, it must be remembered that it was before the celebrated trial of the *Rocket* on the Liverpool & Manchester Railway, which did not occur until October 14, 1829. The form of locomotive engine which is described in Wood's "Treatise on Railroads," and which that Author says, "with trifling modifications," was used on the Stockton & Darlington, the Killingworth, and other railroads in England, had cylindrical boilers, with hemispherical ends and a single cylindrical tube of about 2 ft. diameter, which passed through the boiler and was placed within 2 in. of the bottom. In one end of this tube the fire was placed and the other end was terminated by a chimney. In some engines this tube, instead of passing through the boiler, was made to return and pass out at the same end as the fire-grate. The engines had four wheels and two cylinders, which were placed vertically and attached to the top and partly within the boiler, and were located on the longitudinal center line of the engine, one of them directly over each axle, the piston-rods working through the top cylinder heads with a long cross-head, which extended transversely far enough so that the connecting-rods could be coupled directly to crank-pins to the outside of the wheels. The cranks on the two pairs of wheels were at first maintained at right angles to each other by an endless chain passing over cog-wheels fixed upon the axles of the engine. That Mr. Jervis contemplated some such arrangement as this is indicated by the fact that he speaks of "revolving chains" in his letter. Of these chains Mr. Wood says:

"However good in other respects, this chain had its defects, and it has been superseded by cranks and connecting-rod. By continued working the chain was apt to stretch, and a contrivance was resorted to, of the removal of the chairs (?) from each other, to tighten the chain; but as this could only be done at certain periods, the chain was frequently getting slack. When this took place, and when the full power of one of the cylinders was applied upon one pair of wheels, while the other connecting-rod was upon the center, and therefore not capable of acting at all upon the other wheels, the rotation of the latter depended upon

the action of the chains ; if the chain was, therefore, slack, it occasioned a slipping of the wheel until the links of the chain laid hold on the projection of this wheel in the direction in which the chain was moving round, and this slipping alternately occurred by each of the wheels in succession, as they became a predominant moving power. The chain was therefore laid aside."

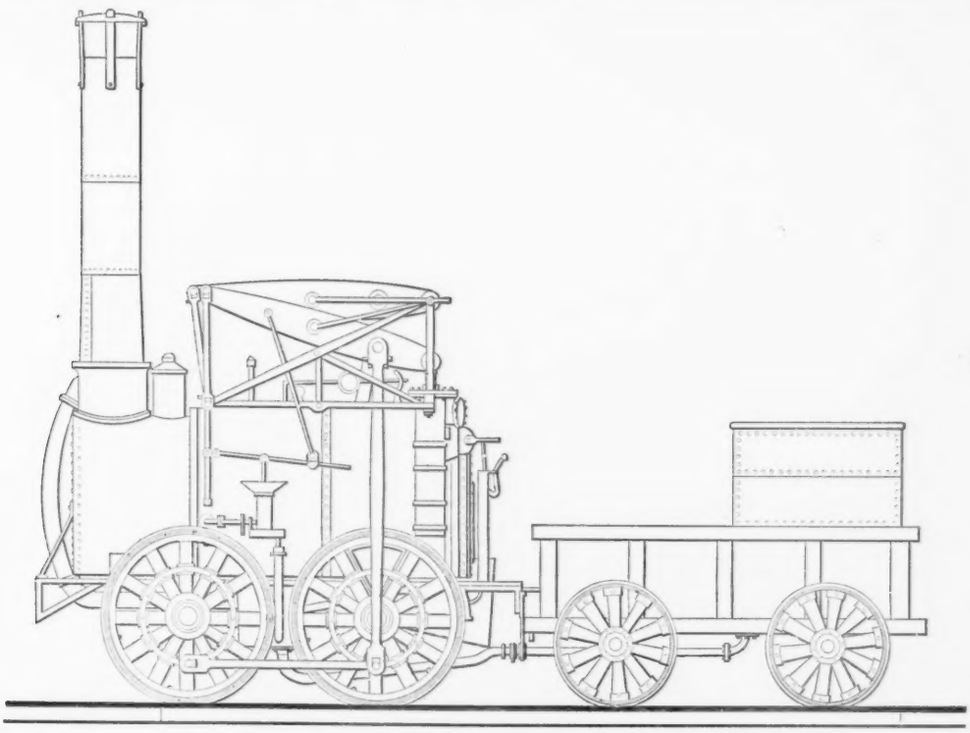
To maintain the cranks on the two pairs of wheels at right angles to each other, "returned cranks" were attached to the outer ends of the crank-pins of one pair of wheels. These return cranks had what may be called secondary pins on their outer ends, which were placed at right angles to the main pin. These secondary pins were connected by coupling rods to the main pins on the other pair of wheels, and thus the two sets of main pins on the two pairs of wheels were kept at right angles to each other.

It should be observed that when Mr. Allen arrived in England the use of the multitubular boiler in locomotive engines was unknown, or was only talked about. In the engraving of the Killingworth engine in Wood's "Treatise," he shows and describes an exhaust-pipe which "is opened into the chimney, and turns up within it;" but the value of the steam blast was then not recognized. The locomotives which were known in America at that date were those which have been described. It is therefore not remarkable that Mr. Allen, then only 27 years of age, and feeling the responsibility of his position, should be governed by the instructions which he received when he left home. He therefore ordered of Messrs. Foster, Rastrick & Company, of Stourbridge, one locomotive of the Stockton & Darlington type, which was the engine that afterward had the distinction of being the first one that was ever run in America. It had four coupled wheels, fig. 1, all drivers, driven by two vertical cylinders, with 36-in. stroke, placed at the back on each side of the boiler. The motion of the piston was transferred through two grasshopper beams above the cylinders, and from those beams by connecting-rods to the crank-pins on the wheels. The front end of the beam was supported by a pair of radius rods which formed a parallel motion. The spokes of the wheels were heavy oak timbers, strengthened by an iron ring bolted to the spokes midway between the hub and felloes, and the latter was made of strong timber capped by a wrought-iron tire. From the illustrations of this engine which have survived, the cranks on each pair of wheels were apparently at right angles to each other, otherwise it is not clear how the engine could start when they were on one of the dead points. The boiler was cylindrical and had several large flues inside.

After Mr. Allen arrived in England, as already stated, he made the acquaintance of George Stephenson, and from him received much valuable aid and advice. He visited Liverpool, the Stockton & Darlington Railway, and Newcastle. Locomotive engines had then been in successful use since 1814, and the subject of railroads was attracting great attention, not only in that country, but in America and the whole civilized world as well.

The following extract from a report of the Second General Meeting of the Liverpool & Manchester Railway, dated March 27, 1829, will show how the subject was regarded. In this report it is said :

> The nature of the *power* to be used for the conveyance of goods and passengers becomes now a question of great moment, on whatever principle the carrying department may be conducted. After due consideration the engineer has been authorized to prepare a locomotive engine, which from the nature of its construction, and from the experiments already made, he is of opinion will be effective for the purposes of the Company, without proving an annoyance to the public. In the course of the ensuing summer it is intended to make trials on a large scale, so as to ascertain the sufficiency, in all respects, of this important machine. On this subject, as on every other connected with the execution of the important task committed to his charge, the Directors have every confidence in Mr. Stephenson, their Principal Engineer, whose ability and unwearied activity they are glad of this opportunity to acknowledge.



THE "STOURBRIDGE LION."

Fig. 1.

On his arrival in England Mr. Allen found, as Mr. Wood, in the preface to his treatise says, that "The eyes of the whole scientific world were upon the great work of the Liverpool & Manchester Railway;" and as another writer of that period reported, "discoveries were daily made of new principles applicable to locomotives, and, extraordinary as they now are, in their power and velocity, great improvements may yet be reasonably anticipated." In England Mr. Allen spent considerable time in visiting the different roads then in operation, and in studying the performance of the locomotives in use. The kind of power to be used on the Liverpool & Manchester Railway was regarded as a question of great moment. In the spring of the year 1829 the Directors of that Company

sent a deputation of their body to visit the lines where different varieties of motive power were employed. The only conclusion which they came to appeared to have been that, from the great amount of traffic anticipated upon the line, horses were inapplicable. The contest then being between locomotive and fixed engines, in order to determine which of the two was the most suitable for the purpose, the Directors resolved to employ two practical engineers, Mr. James Walker and Mr. John W. Rastrick, to report which, under all circumstances, was the best description of moving power to be used. They reported against locomotive and in favor of stationary engines. Notwithstanding this report, the Directors did not feel themselves able to come to a decision on the subject—a leaning in favor of locomotive engines existing, it was said, in a majority of the Directors.

Mr. Allen made a contract with Messrs. Stephenson & Company, of Newcastle, for two more locomotives. These engines, he said, were identical in boiler, engine plan, and appurtenances to the celebrated *Rocket*.

When completed the three engines were shipped to New York and arrived there in the winter of 1828–29. The *Stourbridge Lion*, it is said, was sent from the foot of Beach Street, in New York, to Rondout, and thence reshipped by canal to the track at Honesdale, where it made its celebrated first trip. The other two engines were for a time stored in the warehouse of Messrs. Beale & Dunscom on the East side of New York. One or both of them were there raised up so that their wheels were not in contact with the ground and were exhibited in motion with steam on as a curiosity to the public. The singular part of this is that it is not now known what ever became of these engines. All trace of them has been lost as completely as though they had been cast into the sea.*

Why the *Stourbridge Lion* was sent to Honesdale and not the other engines is not known. If one or both of these, which have since passed into oblivion, had been selected for the first run we would have had the remarkable circumstance that a trial of an engine, which Mr. Allen said was built on substantially the plan of the famous *Rocket*, would have occurred in this country *before that* celebrated event took place in England.

"It is to be regretted," said Mr. Allen, "that one of the Stephenson locomotives was not sent, and for the reason, that they were the *prototypes* of the locomotive *Rocket*, whose performance in October of the same year so astonished the world. If one of the two engines in hand ready to be sent had been the one used on August 9th, the performance of the *Rocket* in England would have been anticipated in this country."

The story of this first trial of the *Stourbridge Lion* has often been told. The engine received its name, Mr. Allen said, "from the fancy of the painter who, finding on the boiler end a circular surface, slightly convex, of nearly four feet diameter, painted on it the head of a lion in bright colors, filling the entire area."

The river and canal being closed by ice, it was not until the opening of navigation in the spring of 1829 that access was had to the railroad at Honesdale, Pa., which was then at the head of the canal and at the beginning of the railroad.

Being at liberty during July and August, Mr. Allen volunteered to go to Honesdale and take charge of the transfer of the locomotive from the canal-boat to the railroad track. Of the place where the trial was made he wrote:

"The line of road was straight for about 600 ft., being parallel with the canal, then crossing the Lackawaxen Creek, by a curve nearly a quarter of a circle long, of a radius of 750 ft., on trestle-work about 30 ft. above the creek, and from the curve extending in a line nearly straight into the woods of Pennsylvania.

"The road was formed of rails of hemlock timber in section 6 × 12 in., supported by caps of timber 10 ft. from center to center. On the surface of the rail of wood was spiked the railroad iron—a bar of rolled iron 2½ in. wide and ½ in. thick. The road having been built of timber in long lengths, and not well seasoned, some of the rails were not exactly in their true position. Under these circumstances the feeling of the lookers-on became general that either the road would break down under the weight of the locomotive, or, if the curve was reached, that the locomotive would not keep the track, and would dash into the creek with a fall of some 30 ft.

"When the steam was of right pressure, and all was ready, I took my position on the platform of the locomotive alone, and with my hand on the throttle-valve handle, said: 'If there is any danger in this ride, it is not necessary that the life and limbs of more than one should be subjected to danger,' and felt that the time would come when I should look back with great interest to the ride then before me.

"The locomotive having no train behind it answered at once to the movement of the valve; soon the straight line was run over, the curve was reached and passed before there was time to think as to its being passed safely, and soon I was out of sight in the three miles' ride alone in the woods of Pennsylvania.

"I had never run a locomotive nor any other engine before. I have never run one since, but on August 9th, 1829, I ran that locomotive three miles and back to the place of starting, and being without experience and without a brakeman, I stopped the locomotive on its return at the place of starting. After losing the cheers of the lookers-on, the only sound, in addition to that of the exhaust steam, was that of the creaking of the timber structure.

"Over half a century passed before I again revisited the track of this first ride on this continent. Then I took care to walk over it in the very early morning, that nothing should interfere with the thoughts and the feelings that, left to themselves, would rise to the surface and bring before me the recollections of the incidents and anticipations of the past, the realization of the present, and again the anticipations of the future.

"It was a morning of wonderful beauty, and that walk alone will, in time to come, hold its place beside the memory of that ride alone over the same line more than fifty years before."

Mr. Allen always took a delight in telling of this early event in railroad history. When the enormous extent of the railroad system of this country is considered, it seems very wonderful that it was created within the lifetime of a single individual, who was an active, and, it may be said, the chief participant in the very beginning of steam locomotion in this country. Less than a year ago the venerable Captain John Ericsson ended his eventful life. He was a participant in the celebrated Rainhill trial of locomotives on the Liverpool & Manchester Railway in 1829. His life and that of Mr. Allen formed links which almost united the eighteenth and the twentieth centuries.

(TO BE CONTINUED.)

* If any reader of this memoir has any knowledge concerning the ultimate fate of these two locomotives, he is requested to communicate it to the Editor of this paper.

THE DEVELOPMENT OF ARMOR.

By First Lieutenant Joseph M. Califf, Third U. S. Artillery.

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(*Continued from page* 12.)

VIII.—PRACTICAL APPLICATION ABROAD.

The first epoch in the practical application of armor to ships began with the building, in 1854, of the five French iron-clad floating batteries, three of which figured so conspicuously at Kinburn in the following year. A number of floating batteries built upon much the same lines were constructed in England during 1854–55, and were despatched to the Crimea, but too late to take part in active operations.

These vessels, with their 4½ in. of iron armor, were unwieldy and possessed little speed, but they marked the beginning of the armor-clad fleets of to-day. The Crimean

War demonstrated not only the murderous effect of shell fire against wooden ships, but also the inability of such ships to reduce ordinarily strong sea-coast fortifications, and led to the laying down, in 1858, by the French Government, of the first sea-going iron-clad ship, the *Gloire*, which has been called the beginning of the second epoch in the development of armor.

As was natural, in planning the first iron-clad the inclination was to protect all the vulnerable parts, so we see this 6,000-ton frigate coming from the hands of the builders clad in a complete suit of mail. The *Gloire* was protected with laminated iron armor extending from below the water-line, where it was 5 in. in thickness, to the top of the gun-deck, where the thickness was reduced to 4½ in.—amply sufficient to resist any ordnance in use at that time.

The English laid down the keel of their first armor-clad ship in 1859, but in it they aimed to give protection only to men and guns, so the *Warrior* took the sea with a 4½-in. armor-belt, extending two-thirds of her length, and from below the water-line to above the main deck battery. But in the next war-ships laid down two years later—the *Minotaur* class—we find complete protection for both water-line and gun decks, with an increase of one inch in the thickness of the armor.

With the necessity for greater thickness of armor to match the gun, it became evident that complete protection for the sides of war-ships was no longer possible, and in the years following the laying down of the first iron clads we see a gradually increasing thickness of plate and as steady a diminution of the surface covered. The introduction of iron and steel in the construction of ships, together with the adoption of improved methods, made it possible to give relatively a greater percentage of the total tonnage to the armor, but the enormous increase in the weight of the armament more than counterbalanced the gain in this direction.

The problem that presented itself to the naval constructor was not only where to take it off—but where to put it on as well—whether protection should be given to the men and the guns, or to the water-line and the vitals. To provide for both, with the maximum displacement then considered feasible, was out of the question. In England, in the *Hercules* type, which followed the *Minotaur*, the water-belt of armor was still retained, and the guns, still in broadside, were collected in an armored central battery.

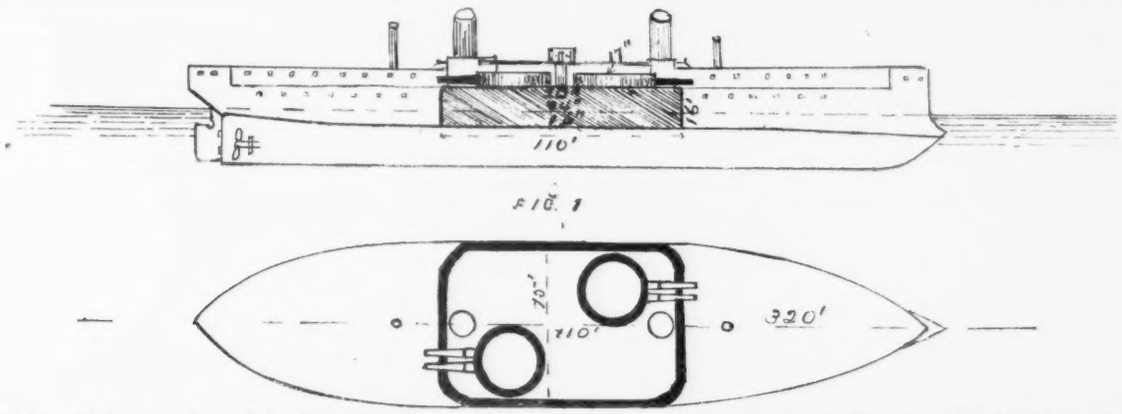
The next step in the distribution of armor was the partial or complete abandonment of the water-line belt, except in the French service, and the taking of the guns of the main battery out of broadside and putting them in heavily armored turrets. In the *Italia* and the *Lepanto* the Italians reduced to its lowest limit the armor-protected area. There is no armor belt, and aside from the armor on the central citadel, or barbette, the only vertical armored protection afforded is that given to the passages leading from the magazines to the battery.

France has, from the beginning, adhered to water-line protection—otherwise, in the grouping of guns and the providing protection for magazines, machinery, etc., by an interior armored deck, has not differed materially from the lines followed by the other powers, but the protection given to the water-line has been, of course, at the expense of that given to guns and machinery.

Within the past two years the introduction of rapid-fire guns has become an assured fact. Added to this, a series of experiments carried on both in England and France to test the effect of projectiles charged with high explosives against the unarmored sides of ships, demonstrated the frightful destruction to both men and material these projectiles would cause. These two events have led to the sudden calling of a halt in the reduction of the armor-covered area of war-ships, and a practical going back to the original type of a wholly protected iron-clad. The experiments with shell containing high explosives demonstrated that a steel plate of very moderate thickness was sufficient to cause explosion without penetration.

In speaking of armor as applied to ships, reference is made ordinarily to the plate applied vertically to the sides, as was the universal practice up to within a comparatively recent period. In recent constructions, however, another method has come into vogue, and the terms vertical and horizontal armor are used to signify the manner in which it is applied to the structures—the latter term having reference to the metal when employed as a protection for the decks, whether upon a flat or inclined surface. The substitution of horizontal for vertical armor, either in whole or in part, is becoming general. All modern war-ships now have a protective armored deck of some kind. In many of the cruisers, vertical armor is entirely omitted, and protection for the vitals is secured by steel armor applied to a protective deck at or below the water-line, supplemented by a proper disposition of coal on top.

In discussions concerning the construction of ships and the disposition of armor, the terms battle-ship—turret or barbette—belted, protected, and partially protected cruisers are constantly met with. Generally speaking, a battle-ship is a vessel of large tonnage, heavily armed and armored, and capable of taking part in any and all naval operations. Turret or barbette refer to the manner in which their heavy guns are mounted, whether in enclosed turrets or above an armored breastwork. In the first case, men, guns, carriages, and loading machinery are afforded complete protection; in the latter, only the carriages and loading apparatus are protected, the guns themselves being in the open, unless, as in some cases, they are provided with a roof or shield against projectiles of the smaller calibers.



The belted or armored cruiser, as it name indicates, is a vessel of high speed and large coal capacity, able to take and keep the sea for a considerable length of time, and for protection has a water-line belt of armor over the whole or greater part of its length, a thick deck of horizontal armor, and a strongly armored conning-tower.

The protected cruiser, usually of smaller tonnage than its prototype, has no vertical armor, and relies for protection upon an armored deck extending from stem to stern, strengthened over the machinery and magazines with coal. In the partially protected cruiser, usually of still smaller tonnage, the protective deck stops short of the ends, and differs from the other only in the extent and thickness of the horizontal armor.

The development of armor in the direction of its practical application to war-ships can best be understood by reference to the accompanying cuts. As has been said, the first iron-clad had its sides completely covered with

armor from below the water-line to include the main-deck battery. With the necessity for thicker armor the protected area grew less, until in the English *Inflexible* (fig. 1) we have an example of extreme concentration both in guns and armor-plate. In it the water-line belt is discarded altogether. A short area amidships is provided with side armor of great thickness, the extremities of which are

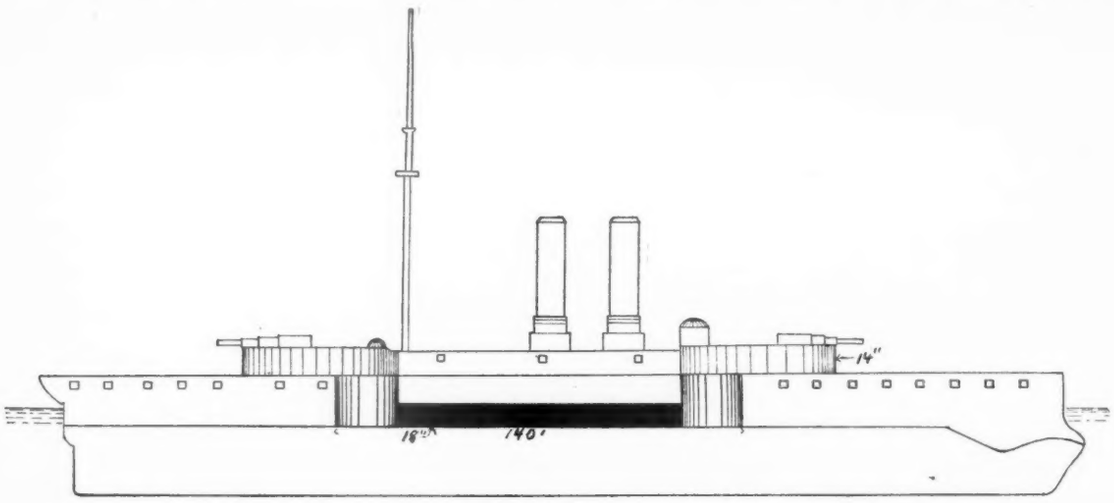


FIG. 2

connected by heavily armored transverse bulkheads, forming a central fort or citadel, wholly enclosed; wherein are mounted all the heavy guns—four in number. Outside of the citadel, the ends are without protection. A 3-in. armored water-tight deck, extending from end to end below water, affords protection for the machinery and magazines. This substructure is so arranged in the matter of water-tight compartments and the use of cork, that it is claimed

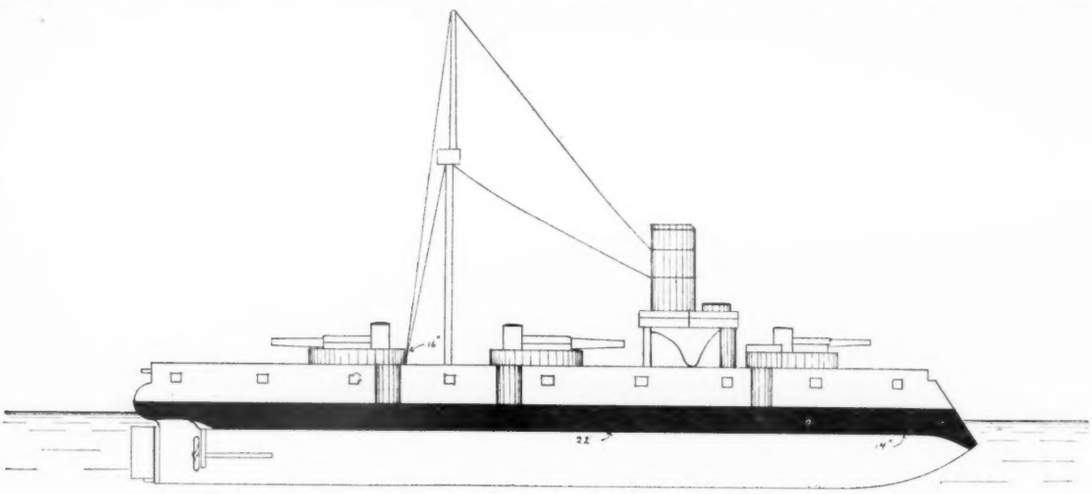
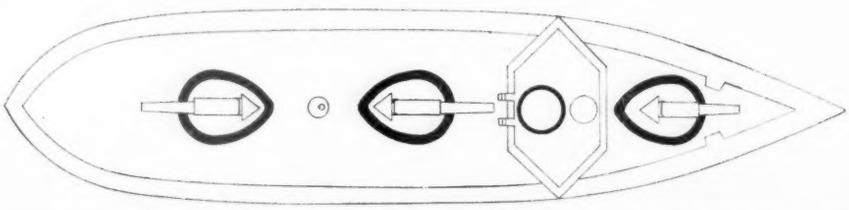


FIG 3



the end superstructures may be riddled with shot, or shot away, without destroying the fighting qualities of the ship or its seaworthiness. This ship, launched in 1876 and completed five years later, was, with her enormously thick armor and four 80-ton rifles, her nearly 12,000 tons displacement, the most powerful war-ship afloat up to within a comparatively recent date. The guns were in pairs in two turrets, placed *en echelon* within the central citadel. The citadel or side armor is of wrought iron, varying in thickness from 16 in. to 24 in. The turrets have 17-in. steel-faced (compound) armor. It has no secondary battery of importance.

The danger of concentrating the entire fighting strength of a ship into one central position, that might be destroyed by a single lucky shot, was apparent, and led to a change in construction in the ships next laid down in England. In the *Collingwood* and sister ships of the *Admiral* class (fig. 2), the gun positions were separated and placed in barbette towers 140 ft. apart, and between these barbettes was placed a heavy auxiliary armament. The barbette towers, the ammunition tubes connecting these with the magazines, and a narrow streak of armor at the water-line, running from the base of one barbette to the other, are the only portions of the ship provided with armor. The auxiliary battery between the barbettes is without protection.

In the separation of the armament, the French, in the *Amiral Baudin* (fig. 3), went to the other extreme. Here each of the three heavy guns which comprise its armament

are mounted in a separate armored barbette tower. The armor is confined to the towers, the ammunition tubes, and a narrow water-line belt. The armor is of steel, with a maximum thickness on the belt of 22 in. amidships, diminishing to 14 in. at bow and stern. The three pear-shaped barbette-towers have 16-in. armor, and are protected against machine-gun fire by umbrella-shaped shields. The armored ammunition tubes are 7 ft. in diameter. In addition to the three 75-ton breech-loading guns of the main battery, there is an auxiliary battery of twelve 14 centimeter guns mounted in broadside, but without protection. The 3 in. of armor on the armored deck is increased to 4 in. over the machinery and boilers.

(TO BE CONTINUED.)

Manufactures.

Iron Production.

THE *American Manufacturer* gives its usual tables showing the condition of the blast furnaces on January 1, and says: "In a condensed form the showing is as follows:

	In Blast.		Out of Blast.	
Fuel.	No.	Weekly capacity.	No.	Weekly capacity.
Charcoal	66	12,693	94	12,237
Anthracite	111	41,964	72	19,356
Bituminous	168	120,345	76	35,126
Total	345	175,002	242	66,719

"This month there is another notable increase in the number of furnaces in blast and their capacities.

"The total number of furnaces in operation on January 1 was 345, and on December 1 it was 337, showing a gain of 8 furnaces in blast, the same gain as was made in December over the previous month.

"The increase in the capacity of the furnaces in blast is from 166,955 tons on December 1, to 175,002 tons on January 1, a gain of 8,047 tons.

"This is quite a remarkable showing, and indicates that the furnaces are being pushed to meet the requirements of a large demand for pig iron. A number of furnaces which were idle for months on account of the unsatisfactory condition of the iron market are repairing and will blow in as soon as possible, while not a few of these furnaces have already done so.

"The summary given below shows the condition of the blast furnaces of the country on January 1, 1890, compared with January 1, 1889:

	Jan. 1, 1890.		Jan. 1, 1889.	
Fuel.	No.	Weekly capacity.	No.	Weekly capacity.
Charcoal	66	12,693	71	13,213
Anthracite	111	41,964	108	31,837
Bituminous	168	120,345	154	97,117
Total	345	175,002	333	142,167

"The above shows 5 less charcoal furnaces in blast January 1, 1890, than on January 1, 1889, and the weekly capacity is 520 tons less.

"There are 3 more anthracite furnaces in blast, and the weekly capacity is 10,127 tons greater.

"There are 14 more bituminous furnaces in blast, with the weekly capacity increased 23,228 tons."

Cars.

THE Elliot Car Works, Gadsden, Ala., have recently filled an order for eight cabouse cars, and a number of coal and box cars for the Alabama Great Southern Railroad.

THE Litchfield Car Company, Litchfield, Ill., is building 2,000 box cars for the Cleveland, Cincinnati, Chicago & St. Louis Railroad.

THE Dunham Manufacturing Company, Boston, reports an unusually large number of orders for car-doors. Over 15,000 of the Dunham storm-proof doors are now in use; they are found on the Grand Trunk, the Chesapeake & Ohio, the Lehigh Valley, the Northern Pacific, the Canadian Pacific, the Atchison, Topeka & Santa Fé, the Lake Shore & Michigan Southern, the Wabash, the Chicago, Burlington & Quincy, and many other prominent roads.

LARGE orders for freight cars seem to be the rule just now, and the car shops all over the country are busy. The fact is, that on many of the roads the equipment has been allowed to run down to a very low point, making extensive renewals an absolute necessity.

THE Pullman Car Works, Pullman, Ill., have an order for 25 passenger cars for the Central Railroad of New Jersey.

THE Rome Iron Company has been organized to build a charcoal furnace and a car-wheel foundry at Rome, Ga. The capital stock is $300,000.

Bridges.

THE Keystone Bridge Company, Pittsburgh, has the contract for the new bridge over the Missouri River at Kansas City for the Kansas City Terminal Railroad.

THE bill introduced in Congress to authorize the bridging of the Hudson River at New York names as incorporators Jordan L. Mott, Thomas F. Ryan, Charles J. Canda, New York; Edward F. C. Young, Jersey City; G. A. Hobart, Paterson, N. J.; W. A. Roebling, F. C. Roebling, Trenton, N. J.; Samuel Rea, William F. Shunk, Philadelphia; Philip E. Chapin, Washington; John K. McLanahan, Hollidaysburg, Pa.; James Andrews, Allegheny, Pa.; John H. Miller, Gustav Lindenthal, Pittsburgh; Henry Flad, St. Louis. The plans, as prepared by Mr. Lindenthal, have been already described; they are for a suspension bridge, with a central span of 2,850 ft. and two side spans of 1,500 ft. each, the roadway to be 155 ft. above high water. The cost of the bridge, not including approaches, is estimated at $16,000,000. It will be fitted to carry 10 tracks.

THE Baltimore & Ohio Railroad is asking for bids for a double-track bridge, to replace the present Bollman truss bridge across the Potomac River at Harper's Ferry.

THE Edge Moor Bridge Works have the contract for the Delaware River Bridge at Phillipsburg for the Central Railroad of New Jersey. The bridge is 1,000 ft. in length, and will consist of three 200-ft. spans, part of the old bridge, and some trestle work.

THE contract for the iron work of the warehouses under the approaches of the Brooklyn Bridge has been let to the Phœnix Bridge Company.

THE Passaic Rolling Mills, Paterson, N. J., recently completed two 18-ton open-hearth furnaces, and are prepared to roll steel angles and shapes. A trial cast was made December 19, which was entirely successful.

THE Pottsville Iron & Steel Company is pushing to completion the new bridge shop. The company is already in the market for girder work.

THE contract for the Alabama River Bridge, for the Alabama Midland Railroad, has been let to the Phœnix Bridge Company. The bridge consists of one 300-ft. draw span and two approach spans of 250 ft. each.

THE King Iron Bridge & Manufacturing Company, Cleveland, O., has the contract for an iron arched bridge for the city of Baltimore.

THE Central Railroad of New Jersey is asking for bids on a four-track bridge of 130-ft. span, to be erected one mile west of Jersey City.

THE New York Central & Hudson River Railroad recently placed orders for two small drawbridges with the Elmira Bridge shops.

An Electric Transfer Table.

THE accompanying illustrations show a transfer table operated by an electric motor, which has lately been put in at the repair shops of the Fitchburg Railroad, in Fitchburg, Mass. The table is 70 ft. in length by 10 ft. wide, and runs on four rails in the pit between the shops; it is used to move cars to and from the tracks in the two parallel shops, each 500 ft. long,

these tracks being 48 in number. It is built in the ordinary way, carrying a single track.

The distinction from an ordinary transfer table here is in the method of operating it, which is by an electric motor on the system of the Union Electric Car Company of Boston. This motor is shown in the drawings, fig. 1 being a plan of that portion of the table where the motor is situated; fig. 2 a side view,

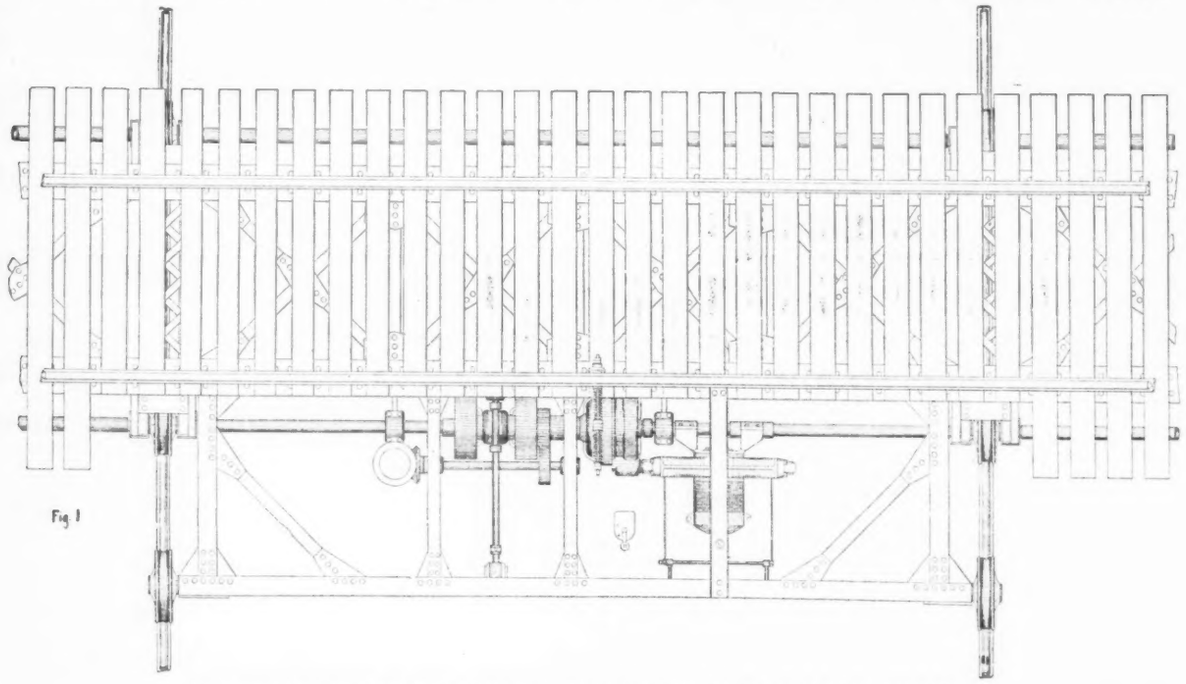


Fig 1

ELECTRIC TRANSFER-TABLE AT FITCHBURG RAILROAD SHOPS.

and fig. 3 a section on a larger scale through the case in which the gearing attached to the motor is inclosed.

The motor is attached to the front axle of the table, and is suspended by bolts from the channel bars forming a portion of the frame, as shown. The gearing is enclosed in a circular case to prevent the entrance of dirt, etc. The last gear in the series is clamped to a long sleeve, which rotates freely on the axle of the table and passes out of the case to clutches, one of which is keyed to the axle, while the other revolves freely on a sleeve. When the clutch collar is thrown in the proper direction, the sleeve is clutched to the shaft, and the motor propels the table. By throwing the collar in the opposite direction the sleeve is connected with the other clutch, which through a proper set of gearing operates the capstan, which is used to haul cars on and off the table. The machinery for shifting the communicator

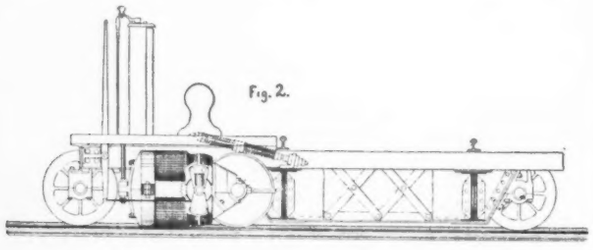


Fig. 2.

brushes reverses the direction of rotation, and consequently the motion of the table, all the movements of which are controlled by a simple electric switch. Two extra bearings are placed upon the shaft to support the extra weight of the motor and gearing. The extension of the table for supporting and enclosing the motor is floored and housed over to protect the operator and apparatus from the weather. The motor can be reached through trap doors in this floor when desired.

Fig. 3, as noted above, shows a horizontal section through the gear case. In this cut *A* is the axle of the car which rotates free of any attachments in the case. The pinion *B* is keyed to the armature shaft, and engages the large gear *C*, which is mounted on the sleeve *D*; this sleeve turns on the shaft *A* on bushings *E E*, and at *F* connects with a pinion which engages the gear-wheels *G G*. These latter are intermediate between the pinion *F* and the internal gear-wheel *H*, enclosing the whole. The gears *G G* are fixed by stud-pins to the spider *K*, which is clamped to the sleeve *I*, and the latter passes through the case to the clutches shown in fig. 1.

The rotation of the pinion *F* causes the gears *G G* to travel around on the internal gear *H*, carrying with them the spider and its attached sleeve. The case is partially filled with a light oil which, when the gears revolve, is carried into every part of the interior of the case, and through proper passages reaches all the bearing surface. The large gears *C C* act as a pump, throwing a constant stream of oil on the motor pinion. This arrangement has been found to work very well, keeping the pinion constantly lubricated and preventing wear in spite of the rapidity of the motion.

The electricity for the motor is furnished from the dynamo which operates the electric lights of the shops. The connection

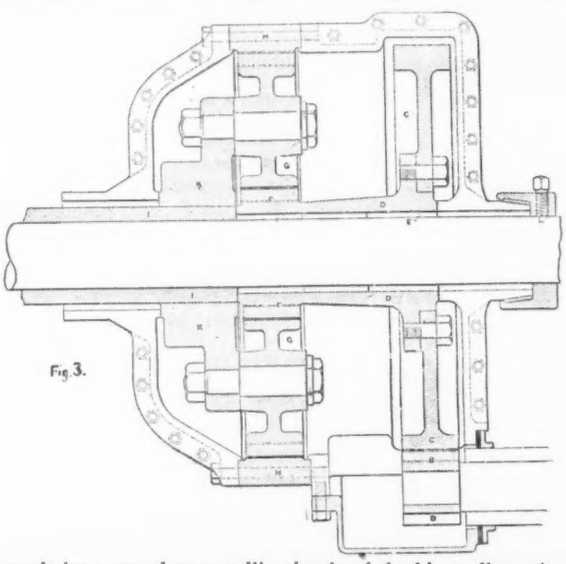


Fig. 3.

is made by a complete metallic circuit of double trolley wires. It has been found in operation that the table can be controlled more quickly and easily than is generally the case with such arrangements. It can be stopped so quickly as to put it in any position desired, matching any of the tracks, and is very easily handled by the operator in charge. The operation of the table and dynamo requires the services of only three men, and the whole arrangement has met with much approval from the officers in charge of the shops, and from other railroad men who have examined it.

The table and motor were designed by the Union Electric Car Company, and the illustrations are from drawings made by that Company.

Lighting Cars.

THE horrible accident which occurred on the Cincinnati, Hamilton & Dayton Railroad on January 17 reiterates with terrible emphasis the necessity for taking every precaution to prevent the repetition of such calamities. In this case, as in other instances of a similar kind, passengers were fastened in the wreck and burned to death in the presence of the onlookers, who could give no aid, and were helpless to prevent the awful agony which was greater than that of a martyr burned at the stake.

Heating by steam is making progress, but not as rapidly as circumstances demand, as is shown by this and other accidents; but the influence of State legislation and the Railroad Commissioners is now exerted in favor of its general introduction; although it will probably require the sacrifice of more lives, the stimulus of public indignation, and the strong hand of the law to overcome the lethargy of railroad directors and managers.

The subject of lighting cars has received less attention than heating, because the danger is less apparent. That carrying several gallons of very combustible oil, which is distributed in a car where, in case of an accident, it will be most effectually scattered, is a source of great danger, is very obvious. Besides this, if cars are ineffectually lighted, it imposes upon passengers from three to six dismal hours in which reading is impossible, and they are driven to reflect on their misfortunes and shortcomings, which leads to a low state of dejection and melancholy.

Railroad companies have not the excuse any longer that there is no satisfactory system of lighting cars excepting oil lamps. It is not our purpose to sit in judgment on the relative merits of the various systems now in use; but it can be said confidently that if there is none better, the Pintsch system is giving satisfactory results. It has been mentioned in these pages before, that an unwillingness to profit by the experience of others appears to be a national defect in the American character. Precedents are, however, useful guides. In the matter under consideration we have the fact before us that the Pintsch system of lighting cars is used extensively in England, Germany, France, Holland, Italy, Austria, Russia, Sweden, Denmark, Switzerland, Egypt, Brazil, and also in this country, on nearly, or quite, 30,000 cars. The use is not recent either, but has extended over a sufficiently long period to fully test the efficiency of the system. The rate of increase also shows that its use has been sufficiently satisfactory to lead to a rapid extension, as from 1883 to 1886 about 23,000 cars were equipped with it. In this country it is used on the New York, Lake Erie & Western Railroad and ferry-boats; the West Shore Road and boats; New York, Providence & Boston; Chicago & Atlantic; New York Central & Hudson River; Boston & Albany; Old Colony; New York & New England; Louisville, New Albany & Chicago; Cincinnati, Hamilton & Dayton roads; Pullman's Palace Car Company; Wagner Parlor Car Company; Providence & Stonington Steamship Company's boats; Hoboken Land & Improvement Company's boats; and the New Jersey Central and the Cleveland, Cincinnati, Chicago & St. Louis Railroads are erecting works for future use. In all over 1,000 cars in this country are lighted by this system.

The following description will give a general idea of its essential features:

PROCESS OF MANUFACTURE.

The material used for the manufacture of Pintsch gas is crude or refined petroleum, or the residual products of coal oil distillation. Crude petroleum is the cheapest material, and the one generally employed. The oil is passed through suitably arranged iron retorts kept at a high temperature by a coal fire below them. The furnace is of such design that the retorts are evenly heated from end to end, and are kept at such a temperature as to thoroughly convert into gas the oil, which is fed into them through specially-arranged pipes and graduating cocks. The product is a rich and permanent gas, and of the highest illuminating power known in the art. From the retorts it passes through water seals, and is led by a pipe to the condenser, where it is cooled. In this it deposits the vapor of water, tar, etc., mechanically carried over with the gas. From the condenser it passes through a washer, which further purifies it, and then through lime purifiers, which effect the removal of all traces of impurities which may still remain. It is then measured and passes to the gas-holders, from which it is drawn by the compressor and stored under any desired degree of compression in the tanks, from which pipes lead wherever it is convenient to convey it for use. The process is a simple one, very direct and economical. A plant capable of making all the gas required for 500 cars is contained in a building 26 ft. 4 in. by 38 ft. 6 in., one story in height. The storage tanks may be placed where it is most convenient, and are larger or smaller in proportion to the requirements of the service.

DISTRIBUTION TO CARS.

From the storage tanks pipes are laid to such points in the yards as are most convenient for charging the reservoirs of the cars. These pipes are provided with suitable valves, and by means of special hose, with quick-acting couplings, the gas is transferred to the tanks under the cars. These tanks are filled to a pressure of 150 lbs. A very much higher compression can be obtained if desired, but experience has shown that it is not good practice to compress the gas more than is needed. The tanks are filled very quickly, and no time is lost on this account, even when the filling is done at an intermediate station. A stop long enough to supply the engine with water or coal, or to change locomotives, is sufficient for filling the tanks.

PRESSURE REGULATION.

At the pressures at which the gas is charged into the tanks, its combustion in lamps is impossible without perfect regulation. This pressure, it should be remembered, constantly though very slowly diminishes as the gas is burned, and the conditions of satisfactory lighting demand that while any gas remains in the tank in excess of atmospheric pressure, it shall give as good a light as when the tank is charged to its full capacity. The regulator is placed under the car, and, without attention, and under all conditions of service, maintains a constant pressure of gas on the pipes leading to the lamps, whether one or all are burning, or none are in use. It is entirely automatic, and when adjusted and put in position needs no further attention, and the cover of the iron box containing it need never be removed.

THE LAMPS.

The lamps manufactured for railroad service are of great variety, and are adapted to every kind of coach. Those for passenger cars are all made upon one principle. They are suspended from the ceiling, and one of the suspending arms furnishes the gas-way. Two or four burners are used, as desired. These are enclosed in glass globes, which perfectly shield them from disturbing air currents, and place them wholly beyond curious or malicious interference. Above the flames is a white porcelain reflector, which greatly aids in the distribution of the light rays, and very much increases the brilliancy of the illumination. These lamps are shadowless; and, as travelers by the lines on which they are employed have observed, four lamps in a passenger coach of full size, give an illumination which permits the passenger to read easily and comfortably.

After the works and the machinery are erected, it is said that this system is cheaper than lighting by oil; it is certainly much cleaner and safer, and, as remarked in the early part of this article, we are not prepared to sit in judgment on all the methods of lighting now before the public, but it may be said confidently, that if no better system can be found than the Pintsch, railroad companies should adopt it in preference to oil, if for no other reason, to prevent such dreadful accidents as the one already referred to and others equally horrible.

Manufacturing Notes.

THE Brown & Sharpe Manufacturing Company, Providence, R. I., received an award of the highest class for its exhibit of machines and tools at Paris.

THE name of the Bucyrus Foundry & Manufacturing Company at Bucyrus, O., has been changed, and it will hereafter be known as the Bucyrus Steam Shovel & Dredge Company. This change has been made in order better to describe the business of the Company, which is principally in the manufacture of steam shovels, dredges, wrecking cars, and similar work. There is no change in the management, but the capital stock will be increased to $150,000, in order to provide for an increase in manufacturing facilities which is necessary.

THE gold medal of the Paris Universal Exposition of 1889 was awarded to Valentine & Company for their coach and railroad varnishes. In addition to the exhibit made by the Company, there were in the Exposition a large number of coaches and carriages built in different countries on which the Valentine varnishes were used, thus giving excellent opportunity to show its quality.

OBITUARY.

HORATIO ALLEN, who died at his residence in South Orange, N. J., January 1, aged 88 years, was for many years prominent as a civil and mechanical engineer. In early life he was connected with the Delaware & Hudson Canal Company and the South Carolina Railroad, and took a prominent part in the introduction of locomotives on American railroads. Later he was for many years the head of the Novelty Iron Works in New York, where the machinery of some of the best-known American steamships was built. Mr. Allen retired from active work some years ago, but continued to take a lively interest in engineering matters. A more extended notice of his work will be found on another page.

WILLIAM STROUDLEY, who died in Paris, December 20, aged 56 years, was born in Oxford, England, and learned the machinist's trade in Birmingham. In 1861 he was made Superintendent of the shops of the Edinburgh & Glasgow Railway; in 1865 Locomotive Superintendent of the Highland Railway, and in 1870 Locomotive Superintendent of the London, Brighton & South Coast Railway. This last position he held until his death, and in it made a great reputation as a mechanical engineer, the locomotives he designed being considered as among the best of the English type. In addition to his purely railroad work, he also had charge of the company's steamers running across the English Channel, and designed the engines of a number of those boats. He was noted among English engineers for his careful attention to details, his keen sense of mechanical fitness, and his excellent judgment.

SAMUEL KEEFER died at his residence in Brockville, Ont., January 7, aged 79 years. He was born in Thorold, Ont., and commenced work in the engineering corps of the Welland Canal in 1827. In 1839 he was made Secretary of the Canadian Board of Works, and in 1841 Chief Engineer. In 1853 he was appointed Engineer of the Grand Trunk Railway, and held that position for four years. From 1857 to 1859 he was Inspector of Railroads, and from the latter year to 1864 Deputy Commissioner of Public Works for the old province of Upper Canada. He had charge of the building of the Suspension Bridge at Niagara Falls, and some time later he surveyed the line of the Baie Verte Canal, and was afterward Secretary of the Canadian Canal Commission. For many years he was connected with almost every important work carried on in Canada. For some years past Mr. Keefer had retired from active work, his only recent public appearance being as a Commissioner in the Canadian Pacific inquiry a year ago. He was a brother of Mr. Thomas Keefer, who was recently President of the American Society of Civil Engineers.

DR. CHARLES A. ASHBURNER died at his home in Pittsburgh, December 24, aged 35 years. He was born in Philadelphia, graduated at the University of Pennsylvania, and at once commenced work as an engineer, being employed on the Government surveys of the Delaware River and in the lighthouse surveys. In 1874 he was appointed Assistant to Professor J. P. Leslie in the Geological Survey of Pennsylvania, in which position he was actively employed until 1880. In that year he was appointed Geologist in charge of the surveys of the anthracite coal fields, and his original methods of surveying and measuring those coal measures attracted much attention. In 1885 he was appointed Geologist in charge of all the field and office work of the survey. Some time ago he removed to Pittsburgh, having been appointed Scientist for the Westinghouse Company and the Philadelphia Gas Company. Although still a young man, he was considered a high authority in geology, and especially in all questions relating to coal and oil. Only a few weeks before his death he had agreed to superintend the collection of statistics on coal and natural gas for the Census of 1890, and his services as consulting engineer were in much demand by mine operators.

PERSONALS.

J. P. WILLIAMS has been appointed a member of the Minnesota Railroad Commission.

G. A. BELL has been appointed General Superintendent of the Troy Iron & Steel Company at Troy, N. Y.

J. A. L. WADDELL, C.E., is Chief Engineer of the new bridge over the Missouri River at Sioux City, Ia.

JOHN W. HILL, C.E., of Cincinnati, has been appointed Chief of Engineers on the staff of Governor Campbell, of Ohio.

CHARLES MACDONALD has been elected President of the Engineers' Club of New York.

ARTHUR G. WELLS has been appointed General Superintendent of the Ohio, Indiana & Western Railroad.

W. B. CHADWICK has been appointed Superintendent of Water-Works at Chester, Pa.

COLONEL T. M. R. TALCOTT has resigned his position as Vice-President of the Richmond & Danville Railroad Company.

PROFESSOR J. W. SPENCER has been appointed State Geologist of Georgia and will have charge of the general survey of the State.

A. J. BURT has been appointed Assistant Auditor of the Michigan Central Railroad, succeeding F. BRAISTED, who has resigned.

I. G. RAWN has been appointed Superintendent of the Richmond, the James River, and the Peninsula divisions of the Chesapeake & Ohio Railroad.

CHARLES WOOD has been appointed Chief Engineer of the Cincinnati, Hamilton & Dayton Railroad. He has been Assistant Engineer for several years.

FRANCIS B. CLARKE has resigned the position of General Traffic Manager of the Chicago, St. Paul, Minneapolis & Omaha Railroad, to devote his time to other interests.

A. A. ROBINSON, heretofore Second Vice-President and Chief Engineer of the Atchison, Topeka & Santa Fé Railroad, has been appointed General Manager of the Company's lines.

H. M. PERRY has been appointed Superintendent of the works of the United States Rolling Stock Company at Hegewisch, Ill., in place of F. W. WILDER, who has resigned.

FRANK LAWLOR, late Division Engineer of the Chicago, Burlington & Quincy Railroad, has accepted a position in the Construction Department of the Western Railroad of Uruguay.

JOSEPH RAMSAY, JR., late Chief Engineer of the Cincinnati, Hamilton & Dayton Railroad, is now Assistant to the President of the Cleveland, Cincinnati, Chicago & St. Louis Railroad.

L. B. MCKEE, C.E., has been appointed Engineer in charge of the construction of the new coal piers and storage trestles of the New York, Ontario & Western Railroad at Weehawken and Oswego.

W. W. PEABODY has resigned the position of General Superintendent of the Trans-Ohio Lines of the Baltimore & Ohio, to become Vice-President of the Baltimore & Ohio Southwestern Railroad.

RICHARD CARROLL has been appointed General Manager of the Cincinnati, New Orleans & Texas Pacific Railroad in place of JOHN C. GAULT, who has resigned. Mr. Carroll has been General Superintendent for a number of years.

JOHN BOGART, State Engineer of New York and Secretary of the American Society of Civil Engineers, has declined the office of Commissioner of Street Cleaning of New York City, which was offered him recently by Mayor Grant.

JOHN HEADDEN has been appointed Superintendent of the King Locomotive & Car Works at Bordentown, N. J. Mr. Headden was for a number of years Master Mechanic of the old New Jersey Railroad, and was afterward with the Rogers Locomotive Works for a long time.

HORACE LOOMIS has been appointed Commissioner of Street Cleaning of New York City by the Mayor. He is a civil engineer by profession, and for some ten years was employed in some railroad work on the New York, Lake Erie & Western and the New York, Susquehanna & Western roads. From 1875 until the present time he has been employed on city work, first in the Croton Aqueduct Bureau, afterward as Chief Engineer of Pavements, and more recently as Engineer in charge of Sewers, an experience which ought to make him a capable officer in his new position. Mr. Loomis is a graduate of the Rensselaer Polytechnic Institute, and a member of the American Society of Civil Engineers.

PROCEEDINGS OF SOCIETIES.

American Society of Civil Engineers.—The 37th annual meeting began in New York, January 15, President Becker in the Chair. The annual report of the Directors showed a total membership of 1,335. The Treasurer's report showed receipts for the year of $39,800 and a balance on hand of $10,924.

The Committee appointed last year to revise the constitution and by laws submitted a report. This report has already been published and considered.

It was announced that the Norman medal had been awarded to Mr. Theodore Cooper, for his paper on American Railroad Bridges. The Rowland prize had been awarded to James D. Schuyler, for his paper on the Construction of the Sweetwater Dam.

The tellers announced the result of the election for officers for the ensuing year, as follows: President, William P. Shinn; Vice-Presidents, A. Fteley and Mendes Cohen; Secretary, John Bogart; Treasurer, George S. Greene, Jr.; Directors, Charles B. Brush, Theodore Voorhees, Robert Van Buren, William Ludlow and William G. Curtis.

At the evening session Mr. Charles Macdonald delivered an address on the Construction of the Hawkesbury River Bridge in Australia, of which he had charge. This bridge, it will be remembered, had seven spans of 416 ft. each, and it was necessary in preparing the foundations for the piers, to go down from 100 to 160 ft. below the surface of the water. The address was illustrated by photographs and views.

January 16, the members of the Society visited the Government Works at Willett's Point, and afterward the Brooklyn Navy Yard. In the evening they attended a reception given them by the Engineers' Club.

Other business transacted at the meeting consisted in several reports presented by Committees. The Committee on the Failure of the South Fork Dam stated that its report was prepared, but recommended that its conclusions be not made public at present, but the report be retained subject to the call of the Society. The reason given is that suits for damages are now pending in the courts of Pennsylvania, and that it is not thought proper to impress any opinions which would influence those suits.

The Committee on Uniform Standard Time reported progress, and submitted a memorial to Congress, asking for such action as may be necessary to legalize the 24-hour system.

The Committee on Impurities in Water Supply reported recommending the collection of information on this subject, and suggesting the employment of an expert.

The Committee on Methods of Testing Structural Material was announced as follows: G. Bouscaren, W. H. Burr, R. W. Hunt, J. G. Dagron, Percival Roberts, H. G. Morse, and H. B. Seaman.

The Committee upon Standard Rail Sections was also announced, but a discussion sprang up upon this matter, and it was finally decided to refer for letter-ballot a resolution discharging this Committee. A motion for the appointment of a Committee on Units for Measurement was also referred to letter-ballot.

Boston Society of Civil Engineers.—At the regular meeting, December 18, Benjamin W. Guppy and William J. Watkins were elected members. The Committee to consider the advisability of urging upon the Legislature the immediate printing of the new map of the State, submitted a report favoring such action. The Society authorized the same Committee to appear in its behalf before the Legislature, and urge the immediate printing of a small edition at least. The Committee on Revision of the Constitution, submitted a draft of a new Constitution and By-laws of the Society which was unanimously passed.

Mr. William E. McClintock, City Engineer of Chelsea, read a paper describing three methods of heating and ventilating school-buildings, which had been used in that city. Mr. Theodore P. Perkins followed with an account of methods of heating and ventilating which had been used in Lynn, and Professor S H. Woodbridge, of the Institute of Technology, described a system well suited for small school-houses. A general discussion upon heating and ventilation of buildings closed the meeting.

New England Water-Works Association.—At the adjourned meeting in Boston, January 8, the following-named gentlemen were elected Resident Active Members: Lewis M. Bancroft, Reading, Mass.; Walter Hale, Westfield, Conn.; Arthur F. Salmon, Lowell, Mass.; F. P. Webster, Lake Village, N. H.; Philip J. Doherty, Boston, Mass.; Charles E. Drake, New Bedford, Mass.; L. R. Forbes, Brookline, Mass. Associate Member: Wilmer Reed, Burlington, N. J.

Mr. W. H. Richards read a paper on Thickness of Cast-Iron Pipes and Special Castings, his paper having special reference to the extension of the water-works at New London, Conn. This was followed by a general discussion, in which it was stated that the general tendency was to make pipes too light.

The Recent Boston Fire and the amount of water used and wasted was discussed. Mr. Brackett opened, estimating the consumption of water at 24,000,000 gallons, and he was followed by Messrs. Tidd, Winslow, Walker, and others.

Leaks in Cement-lined Iron Pipe were discussed by a number of members present.

Worcester Society of Civil Engineers.—The annual meeting was held January 3. Officers were elected for the year, as follows: President, J. H. Shedd; Secretary, M. A. Boyden; Treasurer, F. L. Allen; Executive Committee, E. K. Hill, A. W. Woods, and W. E. Hassen.

Engineers' Club of Philadelphia.—At the regular meeting, December 21, the Secretary presented, for Professor W. H. Burr, some notes on the Application of Electric Motors to Elevated Railroads; also, for Mr. G. W. Chance, a paper on Right of Way.

Mr. James Christie presented Notes on Riveted Joints. He confined his remarks entirely to single-riveted lap joints as commonly used in the circular seams of steam boilers, and gave a history of a series of experiments, an analysis of which shows, he states, that an increase of efficiency was found to be due to the clamping force exercised by the rivet heads, with possibly a slight gain due to better bearing service, and that no instance was known of this binding of the joint, due to increase of rivet area, failing to show an enlarged resistance to rupture.

Mr. Arthur Marichal presented, for himself and Mr. John C. Trautwine, Jr., a translation from the French of a pamphlet published by the prominent hydraulician, M. Bazin, giving the results of very extensive experiments on the Flow of Water over Weirs.

The Secretary presented, for Mr. Walter S. Church, Some Suggestions About Testing the Strength and Tightness, and Rating the Carrying Capacity of the New Croton Aqueduct, N. Y. The object of this paper is to show the advantages and safety of delivering the much larger quantity of water through the Croton Aqueduct, which can be delivered if it is placed under pressure, than by gravity alone; that, at a reasonable outlay, its carrying capacity can be doubled, which would, he considers, ultimately double the commercial value of this great aqueduct.

Mr. Edward Hurst Brown presented a paper upon the Æsthetic Value of Engineering Constructions.

There was considerable verbal discussion of several of the above-mentioned papers.

THE annual meeting was held in Philadelphia, January 11. The retiring President, Mr. William Sellers, delivered his annual address, which was devoted to the proper limitations of manner training schools and the character of instruction which should be given therein, and also to good highways and the proper method of obtaining them.

The Secretary and Treasurer presented his report, showing the Club to be in good financial condition. The membership includes two honorary, 481 active, and 16 associate members.

The tellers reported the following officers elected for 1890: President, Professor H. W. Spangler; Vice-President, Wilfred Lewis; Secretary and Treasurer, Howard Murphy; Directors, John T. Boyd, George Burnham, Jr., E. V. D'Invilliers, Henry G. Morris, and S. M. Prevost.

The Committee on Revision of Rules presented a report with regard to the election of members, which was referred to the Board of Directors.

The Secretary presented, for Professor L. M. Haupt, Secretary of the Committee on Better Roads of the University of Pennsylvania, the conditions of competition for the prizes of $400, $200, and $100 for the three best papers on Road-Making and Maintenance. A full descriptive circular can be had on application by mail to Professor L. M. Haupt, at the University of Pennsylvania, Philadelphia.

A Committee was appointed to arrange for a Club reception. The new President then took his seat and made a short address.

Engineers' Society of Western Pennsylvania.—At the regular meeting in Pittsburgh, November 19, W. G. Bell, W. A. Cornelius, C. H. W. Ruhe and J. J. E. Wolffe were elected

members. A committee to collect facts and data of interest to engineers on the Johnstown disaster was appointed, the members being A. Dempster, T. P. Roberts, A. Snyder, and Charles Davis. A committee to nominate officers was appointed, the members being William Thaw, Jr., H. D. Hubbard, and F. C. Phillips.

Mr. Arthur Kirk read a paper on the Use of Dynamite in Breaking up the Jam at Johnstown, which called out a general discussion.

Engineers' Club of Cincinnati.—The second annual meeting of the Club was held on the evening of December 19, with 29 members present.

Two applications for membership were received and four new members were elected, making a total membership of 90 at that date.

The following officers were elected to serve during the ensuing year: President, G. B. Nicholson; Vice-President, R. L. Read; Directors, K. E. Hilgard, L. W. Mathewson and Ward Baldwin; Secretary and Treasurer, J. F. Wilson.

The Treasurer submitted his report of receipts and expenditures, and the retiring President read a very interesting address on the progress of engineering during the past year. A bountiful supper supplemented the evening's entertainment.

Western Society of Engineers.—At the annual meeting in Chicago, January 8, the following officers were elected for the ensuing year: President, L. E. Cooley; Vice-Presidents, Robert Shaler and William R. Northway; Secretary and Treasurer, John W. Weston; Trustee, Benezette Williams.

Civil Engineers' Club of Cleveland.—At the regular meeting in Cleveland, O., January 14, Sydney H. Short, F. E. Bright, and L. E. Holden were elected members.

Mr. A. Mordecai read a paper on the Harbor Facilities of Cleveland, comparing especially its facilities for handling coal and ore with that at other lake ports.

Mr. Edward Lindsay exhibited a model of a device of his own for unloading cars, which consists essentially in running the car into a cylinder whose center is a little below the car floor. The car is then held in a suitable manner and the cylinder revolved, so as to place the car upside down, emptying its contents into carts below.

Mr. J. H. Sargent read a paper on a Belt Line Railroad, advocating the extension of the breakwater, the building of a series of slips, and the formation of a system of docks giving a large increase in the lake front, with a belt line connecting these docks with all the principal railroads entering Cleveland.

Engineers' Club of St. Louis.—At the regular meeting in St. Louis, December 18, the Executive Committee announced the result of the ballot for officers for 1890 as follows: President, F. E. Nipher; Vice-President, George Burnet; Secretary, William H. Bryan; Treasurer, Charles W. Melcher; Directors, E. D. Meier and S. Bent Russell; Librarian and Manager, J. B. Johnson; Manager, J. A. Seddon.

Addresses were made by the new and the retiring presidents.

B. H. Colby was elected a member. The receipt of several valuable books and photographs for the library was announced. A communication in relation to the Eads monument was referred to the special committee on that subject.

Professor J. B. Johnson, Chairman, presented a report for the Committee on National Public Works; ordered that the report be accepted, and the committee discharged. Professor Johnson also announced that the Board of Managers had, at its recent meeting, decided to change the place of publication of the *Journal* to Chicago, about April, 1890, and that an address was being prepared on the subject of a national organization of engineers.

Mr. Nils Johnson showed the club a pump valve, which had been operated under a pressure of 550 lbs. for 15 minutes with ordinary hydrant water.

AT the regular meeting in St. Louis, January 8, the Executive Committee submitted a programme of meetings and papers for the year, including a number of papers by well known engineers on important subjects.

Mr. B. F. Crow read a paper on a Method for Definite Location of Gauge Line on Car-Wheels. He discussed the matter principally with reference to street railroad practice, showing the present lack of uniformity. The paper was discussed by members present.

Professor J. B. Johnson read a paper on Deflection of Framed Structures, to which he had added a discussion of the distribution of stresses over redundant members. This paper was generally discussed, several members calling attention to the importance of the question, and to the fact that too little attention is generally paid to it by engineers.

Civil Engineers' Society of St. Paul.—At the regular meeting in St. Paul, Minn., December 2, G. L. Cresson was elected a member.

The paper of the evening—on Methods of Taking Topography over Extended Areas—was read by Mr. F. Freyhold.

Engineers' Club of Kansas City.—At the annual meeting, December 4, the Secretary reported that 12 meetings of the Club had been held during the year. There were now 83 members in all. Candidates for officers for 1890 were named. The Secretary also reported that 16 papers have been presented during the year, besides the general discussion of Sewerage at the November meeting.

The Annual Banquet and a Field Meeting in September were notably pleasant features of the year.

The Committees on Bridge Reform, National Public Works, Transfer of Members and Affiliation of Engineering Societies have done considerable work, but in each case developments from outside are awaited before further action is taken.

A Committee on Cements and Mortars has been appointed, from which we shall no doubt receive valuable information in the future.

AT the regular meeting, December 2, Thomas Callahan was chosen an associate member.

The subject of Sewer Ventilation was discussed by Messrs. G. W. Pearsons, H. H. Filley, F. E. Sickels, and K. Allen.

Mr. F. E. Sickels then read the paper of the evening, on Snow Plows, illustrated by models from actual practice and drawings.

Civil Engineers' Association of Kansas.—The annual meeting was held in Wichita, Kan., December 18. The following officers were elected for the ensuing year: President, Professor W. A. Crusinberry; Vice-Presidents, O. Mulvey and R. W. Luttrell; Secretary, J. C. Herring; Librarian, H. H. Jackman; Treasurer, W. R. Kesler.

Meetings are held on the evening of the second Wednesday in each month, when papers of general interest to the profession are read and discussed. Visiting engineers are always welcome at the meetings, and at the Library of the Association.

Iowa Civil Engineers' and Surveyors' Society.—The second annual meeting was held in the City Hall, at Des Moines, Ia., beginning December 27, with a good attendance of members. The report of the Secretary, Mr. Seth Dean, showed an increase of new members during the year and no losses, there being at present 40 members on the list. Arrangements have been made to exchange proceedings with the State societies of Ohio, Indiana, Illinois, Michigan, Connecticut, and Arkansas, and with the surveyors' associations of Ontario and of the Dominion of Canada. Treasurer Macdonald's report showed a small balance in the treasury.

President Gilchrist then delivered his annual address, which contained many valuable suggestions for the welfare of the Society.

A paper on the subject of Street Pavements was read by Mr. Steyh, City Engineer of Burlington, who discussed the merits and defects of the various kinds of pavement, and recommended for most cities a trial of brick, as being both cheap and durable, and also free from noise and easily cleaned. This paper was followed by an extended discussion of the question, covering not only the paving question but the manufacture of brick and the necessary qualities of clay required for that purpose.

After adjournment the members by invitation inspected the Des Moines Street Railroad and its plant.

On the second day, the report of the Executive Committee was presented, favoring the incorporation of the Society and the commencement of a library. The Committee was instructed to procure the necessary act of incorporation.

Mr. R. G. Brown read a paper on Race Tracks, giving an explanation of the principles involved, both practical and mathematical, in laying out the several forms of track in general use.

Secretary Dean read a paper on the Law of Accretion, from which it appears that the law is not by any means uniform in different States on this question. This paper was generally discussed.

Mr. M. Tschirgi, City Engineer of Dubuque, read a paper on the subject of Water Works for small towns.

Officers for the ensuing year were then elected as follows: President, E. M. Gilchrist, Keokuk; Vice-President, M. Tschirgi, Dubuque; Secretary, Seth Dean, Glenwood; Treasurer, F. A. Macdonald, Burlington; Directors, M. R. Laird, Charles Bennett, Des Moines.

The members then inspected the works of the Des Moines Tile Company, seeing in operation the manufacture of drain-tile and paving-brick.

After the excursion the usual resolutions of thanks, etc., were passed, and the Convention adjourned.

New England Railroad Club.—At the regular meeting in Boston, January 8, notes on European Travel and Railroad Practice in Europe were submitted by Messrs. John Coghlan, Firth, and A. J. Pitkin; these gentlemen describing what they had seen in England, France, Germany, Russia, and other countries, and comparing practices there with our methods at home.

Western Railway Club.—At the regular meeting in Chicago, January 21, the first subject for discussion was the Ventilation of Cars, and on this an elaborate paper by Mr. W. G. Creamer was read and afterward discussed.

The second subject was the Efficiency of the Link as Compared with other Valve Motions.

Montana Society of Civil Engineers.—At the regular meeting in Helena, Mont., December 21, a Committee was appointed to make arrangements for the annual meeting. Officers were nominated for the ensuing year.

A SPECIAL meeting was held in Helena, January 11, to take action upon the death of the President of the Society, General B. H. Green. A Committee composed of Messrs. Keerl, De Lacy, and Haven was appointed to draft a memorial and have the same printed in pamphlet form, with a likeness of the late President. It was resolved to dispense with the excursion and dinner arranged for the annual meeting and to confine that meeting strictly to the transaction of business.

Northwest Railroad Club.—The first annual meeting was held in St. Paul, January 4. The Secretary reported a total of 40 members. The President made a short address, speaking of the progress made by the Club during the year.

The following honorary members were chosen: W. A. Scott, T. E. Clarke, C. W. Case, and H. A. Towne. The old officers were elected, as follows: President, W. T. Small; Vice-Presidents, W. T. Reed, G. F. Wilson; Secretary, H. P. Robinson; Treasurer, H. L. Preston.

It was decided to appoint as subject of discussion for the next meeting the circular of the Master Mechanics' Committee on Axles for Heavy Tenders.

NOTES AND NEWS.

A Pneumatic Street Railroad.—A street railroad about 1½ miles long, on an entirely new principle, is being constructed in Washington, by the Judson Pneumatic Railway Company of New York. In this system, power is to be transmitted by compressed air from a central station to a series of motors placed beneath the track at intervals of about 1,500 ft. In a conduit between the rails, similar in construction to a cable-railway conduit, revolves a smooth cylinder, or series of cylinders coupled together at the ends about 6 in. in diameter. These cylinders are to be kept in continuous rotation by the compressed-air motors. An adjustable blade or arm projecting from the bottom of the car, and passing through the narrow slot into the conduit, carries at its end a group of friction-wheels, which may be pressed down forcibly upon the upper quarter of the revolving cylinder. The plane of revolution of these friction-wheels may be changed by an ingenious device controlled by a lever, to be operated by the driver of the car. While the friction-wheels revolve in the same plane as the cylinder, the frame supporting them is at rest, but the moment the axes of the wheels are thrown out of line with that of the cylinder, by a movement of the lever, the frame is driven along the cylinder by the diagonal travel of the wheels, which is similar to that of the traveling ink-distributer on some of the old-fashioned printing-presses. The speed of the car is regulated by the angle of inclination of the friction-wheel axles, the cylinder revolving continuously in one direction at a uniform speed.

The First Compound Locomotive.—We have lately received information which appears to show that the United States was the first country in which a successful compound locomotive was built and operated. About 1870 or a little earlier the Remington Company built at their works at Ilion, N. Y., some steam-actuated suburban cars for the Worcester & Shrewsbury Railroad, and one of them had the engines compound. The motors were used on a grade of 185 ft. to the mile, and they worked very satisfactorily, but the compound was noted as being more powerful and much more economical on the fuel than the others. This machine had an upright boiler with a steam superheater on the top. There were two cylinders, one 5 × 12 in., the other 8 × 12 in., connecting with crank-pins outside of the wheels, set at right angles. The cylinders were inclined about ¾ in. to the foot. A common shifting-link motion was used to actuate ordinary slide-valves. Provision was made for using steam direct from the boiler in both cylinders when starting and when the work to be done was particularly heavy. When working live steam in both cylinders it was supplied through the steam-chest for the high-pressure cylinder, and exhausted direct into the stack, each cylinder having been provided with an exhaust-pipe that led to the atmosphere. When working compound the steam passed from the high-pressure cylinder through the superheater to a steam-chest connected with the low-pressure cylinder, the superheater and steam-chest acting as a receiver. Changing from simple working to compound was done by means of an intercepting valve which was located in the steam-chest of the high-pressure cylinder. This was a D slide-valve, with ports in cylinder for the exhaust steam either to pass out to the atmosphere or to the receiver of the large cylinder, according to the position of the valve. When the valve was in position to allow the exhaust steam from the small cylinder to go out to the atmosphere, the passage for live steam was open to the chest of the large cylinder, and when the valve was changed to send the exhaust steam into the receiver the passage for live steam was closed.

The motor was built after the design of the patentee, who also invented the Baxter engine. After working for several years the boiler failed, and the machine was taken to the Rhode Island Locomotive Works, where a new boiler was put in with submerged flue tubes. After this change the motor worked without the superheater part of the receiver, and was said to be still more efficient. It was at work till within a very few years. This information we have received through the kindness of Mr. D. A. Wightman, of the Pittsburgh Locomotive Works, and Mr. H. F. Colvin, of the Rue Manufacturing Company.—*National Car & Locomotive Builder.*

Behavior of Steel under Mechanical Stress.—Mr. C. H. Carus-Wilson read a communication on this subject before the Physical Society (British) on December 6 last, of which *Nature* gives the following abstract:

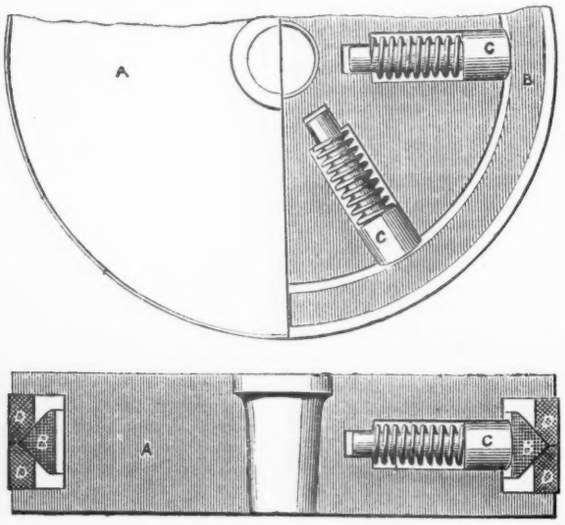
"This is an inquiry into the properties of steel as illustrated by the *stress-strain* curves given in automatic diagrams from testing machines, and by magnetic changes which take place during testing. After pointing out that the permanent elongation of a bar under longitudinal stress consists of a sliding combined with an increase of volume, the Author showed that the yield is caused by the limit of elastic resistance (ρ) parallel to one particular direction in the bar (generally at 45° to the axis) being less than along any other direction. When this lower limit is reached, sliding takes place in this direction until the hardening of the bar caused thereby raises the limit of elastic resistance (in the direction referred to) to that of the rest of the bar, after which the stress must be increased to produce further permanent set. From considerations based on the stress-strain curves of the same material when hardened to different degrees by heating and immersion, etc., it was concluded that the increase of ρ during yield is the same for all the specimens, and that the yield is a measure of the hardness. The question of discontinuity of the curves about the yield point was next discussed, and evidence to the contrary given by specimens which show conclusively that the yield does not take place simultaneously at all parts of the bar, but travels along the bar as a strain wave. In these specimens the load had been removed before the wave had traversed the whole length; and the line between the strained and unstrained portions could be easily recognized. As additional evidence of continuity, the close analogy between the stress-strain curves of steel of various degrees of hardness,

and the isothermals of condensable gases at different temperatures, when near their point of liquefaction, was pointed out; the apparent discontinuity in the latter probably being due to the change from gas to liquid taking place piecemeal throughout the substance. In seeking for an explanation of the hardening of steel by permanent strain, the Author was led to believe this due to the displacement of the atoms within the molecules of the substance. To test this hypothesis, experiments on magnetization by stretching a bar in a magnetic field were made; these show that the magnetization increases with the stress up to the yield point, and is wholly permanent when approaching that point. On comparing his results with Joule's experiments on the elongation of loaded wires produced by magnetization, the Author infers that there are two kinds of elongation—first, that produced by relative motion of the molecules, and secondly, an elongation resulting from a straining of the molecules themselves. To this latter straining the hardening by permanent strain is attributed, and this view seems compatible with the results of Osmond's researches on the hardening of steel."

An Air Pump of 1675.—At a recent meeting of the British Physical Society the President exhibited the air pump constructed by Otto von Guericke in 1675, which had recently been acquired by the Physical Society. This pump is still in a thoroughly workable condition, with the exception of the glass vessel, which has been renewed. The pressure in this receiver could be reduced to 20 mm. of mercury, by means of the pump. The celebrated Magdeburg hemispheres have also come into the possession of the Society, and were exhibited at the same time; they are perfect except in the want of the leather packing.

Vortex Blast Pipe.—In an inaugural address to the Society of Civil and Mechanical Engineers, Mr. Henry Adams, Professor of Engineering at the City of London College, in referring to the visits paid by the Society during the past year to the works of the London & Southwestern Railway, stated that, through the economy effected by the vortex blast pipe, of which Mr. William Adams, the Locomotive Superintendent of that line, and himself were the joint inventors, the saving to the company on its coal bills had amounted to nearly £50,000, independent of other advantages from its use.

A Solid Block Piston.—The accompanying illustration, from the London *Engineer*, shows a design for a solid block piston, made by Mr. T. Thompson, of Leeds, England, and patented by him in that country. Its construction will be



readily understood: *A* is the piston block; *B* the internal ring; *C* plungers with springs; and *D* the packing rings. This piston is said to be giving perfect satisfaction to those using it.

Compound Locomotive for South America.—A compound locomotive of the Worsdell and Von Borries system has recently been completed at the Hyde Park Locomotive Works, Glasgow, Scotland, for the Argentine Midland Railroad. The engine is of the American type, with four coupled drivers and a four-wheeled truck, and has one high-pressure cylinder on one side of the engine and a low-pressure cylinder on the opposite side. The principal dimensions are as follows: Diameter of high pressure cylinder, 16 in.; diameter of low-pressure cylinder, 23 in.; stroke of both cylinders, 24 in.; diameter of driving-wheels, 5 ft. 6 in.; grate area, 16.5 sq. ft.; heating surface, fire-box, 79 sq. ft.; heating surface, tubes, 822 sq. ft.; heating surface, total, 901 sq. ft. The total weight of the engine in working order is 38¼ tons, of which 23¼ tons are carried on the driving-wheels. The tender is carried on two four-wheeled trucks.

An Electric Engine Controller.—Mr. E. Dixon, of Hull, England, has invented and patented an apparatus intended to cut off the supply of steam to an engine by means of a current of electricity, the advantage being that the motion of the engine can be arrested almost instantly by completing an electric circuit at any part of a shop.

Fig. 1 shows a side elevation and fig. 2 a front elevation of the apparatus itself, which is connected by suitable gearing (not

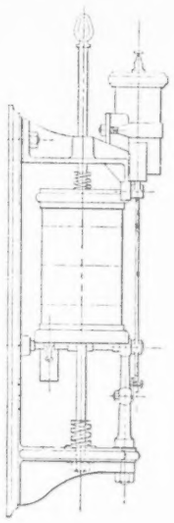


FIG. 1.

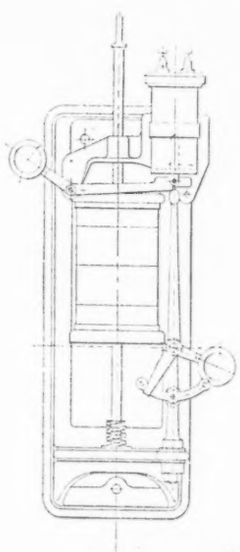


FIG. 2.

shown in the figures) to the lever of the throttle-valve of the engines. The apparatus consists essentially of a raised weight, which is capable of sliding on a central spindle. This weight is held in a raised position by means of a catch lever. This lever carries a soft iron core, which is situated in a solenoid shown at the top right-hand corner of the figures. This solenoid, when connected with an electric battery, raises the soft iron core inside and lifts the catch lever. The weight is thus disengaged and falls. The top of the spindle which passes through the weight is attached to a chain or other mechanism, and by this means the throttle-valve is closed. The coiled spring shown at the bottom of the spindle under the weight acts as a buffer. The apparatus has been successfully applied to several engines, and seems capable of still further applications.—*The Steamship.*

Water Power for Electric Lighting.—We note from our foreign exchanges that much interest is being taken in the utilization of water power for electric purposes. The *Zeitschrift für Elektrotechnik* describes an electric lighting plant at Gastein, in Austria, the power for which is supplied by the River Ache. The available head of water is about 70 ft., and the turbine wheel used gives about 120 H.P., making 140 revolutions per minute. The water is conveyed to the wheel through a 28-in. pipe 230 ft. long, and besides the lighting plant drives two small mills and a small pumping plant in connection with the hot springs at that place. There are four dynamos, one held in reserve, and the plant supplies 1,000 incandescent lamps of 16 candle power each.

Another recent application of water power is at St. Hilaire, France, where the electric lighting station is on the banks of the small River Vouroux, 2½ miles from the town. The water is stored up in three reservoirs, about three hours being necessary to fill them, and the supply thus obtained works two water-wheels successively for eight hours a day. The wheels are 16½ ft. in diameter, and at a speed of seven revolutions per minute develop 10 H.P. each.

In Austria preparations are being made to light the town of Trient by water power. The lighting station at Innsbruck in the Tyrol takes its power from a small river about two miles away, the dam being so located as to give a head of no less than 377 ft. The power available amounts to over 600 H.P., but only two turbines of 150 H.P. each are at present in use.